The Implications of Park and Ride for Urban Development Strategies in major metropolitan areas in New Zealand

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List of Acronyms

Acronym	In Full
AHP	Analytical Hierarchy Process
ARGF	Auckland Regional Growth Forum
BRT	Bus Rapid Transit
CBD	Central Business District
CPRE	Council for the Protection of Rural England
EHTF	English Historic Towns Forum
GCUDS	Greater Christchurch Urban Development Strategy
GCUDSF	Greater Christchurch Urban Development Strategy Forum
HOV	High Occupancy Vehicle
IHT	Institution of Highways and Transport
LTMA	Land Transport Management Act 2003
MoT	Ministry of Transport (New Zealand)
ODPM	Office of the Deputy Prime Minister (UK Government)
PPT	Public Passenger Transport
PR	Park and Ride category type
PTUA	Public Transport Users Association
RLTS	Regional Land Transport Strategy
RMA	Resource Management Act 1991
TRB	Transportation Research Board
TRL	Transport Research Laboratory
UDS	Urban Development Strategy
UF	Urban Form category type
VTPI	Victoria Transport Policy Institute
WBOP	Western Bay of Plenty
WRLTS	Wellington Regional Land Transport Strategy
WRSF	Wellington Regional Strategy Forum
WSS	Weighted Summary Score

Abstract

Many cities, including some in New Zealand, are investigating, developing or implementing urban form strategies and, separately, Park and Ride systems. These two matters are not generally considered alongside one another. This paper explores the relationship and interactions between urban form and Park and Ride systems through the identification of objectives for each, and considering the degree to which objectives of various urban form types may be achieved with different types of Park and Ride systems.

The purpose of this research project is to investigate and develop a predictive methodology that would allow the identification of the most suitable Park and Ride system (from a proposed classification scheme) for a given set of urban form objectives.

Classification systems for urban form and Park and Ride systems are proposed in light of information from an extensive literature and information review. They are used as a basis for an Assessment Framework Matrix of urban form type against Park and Ride type. The matrix is populated from a spreadsheet-based analysis process, which considers the degree of achievement of urban form objectives by various Park and Ride categories. This process is hampered by the lack of (easily accessible) data, particularly for strategic assessment of existing Park and Ride systems worldwide.

A range of tests are conducted on the proposed Assessment Framework Matrix using real cities, a range of hypothetical urban areas, and several sensitivity tests. Subsequently, a case study applies the matrix to Christchurch, New Zealand.

The main findings of this research project indicate that the proposed methodology works, needs refining with better data, could be useable in public or stakeholder engagement processes, and would benefit from a “User Manual” and some simplification. The case study tentatively indicates a recommended Park and Ride system type for Christchurch.

Chapter 1 Introduction

Often an urban area, when facing growth-related issues and difficulties such as increasing transport demand, will look at how other urban areas have sought to address these problems. Solutions which are novel to the experiences of the developing urban area can catch the attention (or even envy) and a desire to pursue or apply these new solutions grows. This can be readily seen in regard to the resurgence of interest in light rail across the developed world and more locally Park and Ride systems.

The Canterbury Regional Land Transport Strategy 2005-2015 defines Park and Ride as a system where individuals can park their private vehicles at bus or train stations, employment sites or major activity centres and then travel by public passenger transport to their end destination.

It is the role of the professional planner to ensure that these new solutions are well understood and that they are not simply introduced in blind faith believing that a "one-size-fits-all approach" will result in the resolution of the original problems that generated the interest. Rather a proper analysis and checking of whether and how these solutions may be best introduced to an urban area is required and will significantly increase the chances of a successful outcome.

In the case of Park and Ride, it can be tempting to simply have a policy decision entered into which ultimately results in the implementation of a Park and Ride system for an urban area. There are a number of national level strategic transport policy documents which support Park and Ride in principle (Ministry of Transport, 2002; Office of the Deputy Prime Minister (ODPM), 2000). But as there are a number of types of Park and Ride, it is important that the right type is chosen to maximise the chances of fulfilling the objectives set for it. If the wrong type of system is introduced it may not ever achieve its original objectives (addressing the motivating issues), may create sub-optimal results and at worst, make the whole situation worse than the initial conditions. For example, there are concerns that certain types of Park and Ride may run counter to Transit-oriented development and in fact encourage urban sprawl (Victoria Transport Policy Institute (VTPI), 2005) and may encourage commuting from rural areas (Institute of Highways and Transport (IHT), 2005). Indeed some researchers have suggested that "park and ride is not appropriate everywhere" (English Historic Towns Forum (EHTF), 2000).

Others, such as Parkhurst (2000), consider that policy decisions should be made holistically. In that light, decisions related to pursuing initiatives such as Park and Ride should consider wider impacts than only the transport implications.

However, Park and Ride as a policy tool or transport planning measure exists at a much more detailed level of policy development than urban development strategies or urban form policy. Park and Ride systems and policy are potential components of the integrated, sustainable transport strategies which should relate to, link to and complement the wider urban form strategies or strategic policy for the area of implementation. This issue is likely to have contributed to the linkage having had little consideration in the past, and is potentially a source of difficulty in pursuing an objective of this study, that is creating a predictive framework relating the two in later stages of this project. This project intends to address this linkage and in conjunction, consider the implications of Park and Ride for urban development strategies in major metropolitan areas in New Zealand.

1.1 Scientific Problem

Worldwide cities experiencing consistent growth are being confronted with increasing problems associated with their transport system and difficulties meeting the demands being placed upon them. In response, many cities have or are developing strategic transport policy to address the issues and guide future development of the transport systems. Many other cities are refocusing their existing metropolitan level transport strategies in new directions as the previous paradigms and proposals are not (or do not appear to be) working.

In many of these new strategic transport policies, cities are looking to implement and/or further develop Park and Ride systems as a component of a wide suite of measures. Park and Ride systems provide an option that takes advantage of the benefits of car or personal vehicle travel and public transport travel for differing sections of a journey. Commonly, this involves a car park site which is served by public transport services (rail or bus-based usually). A more extensive description is provided in section 2.2 Park and Ride.

There is a widespread feeling by many across the world, including many politicians, that Park and Ride should produce good transport outcomes, as it combines the individual benefits of car travel and broader benefits of public transport travel in some balance which provides an optimum solution for achieving a range of objectives such as reducing congestion, promoting public transport use, reducing pollution, or supporting a particular precinct (e.g. central city). However, literature (Parkhurst, 1996) indicates that there has in fact been little objective research undertaken to confirm this. Further there appears to be no research regarding the classification of Park and Ride systems to review how differing operational styles or types may produce different results in various contexts.

At the same time, many of the cities considering Park and Ride systems are also seeking to create and implement land use development strategies (sometimes known as Urban Development Strategies, Urban Growth Strategies or Growth Management Strategies) in response to the demands of accommodating growing populations (and associated growth in households and other community facilities). These Urban Development Strategies (UDS's) almost uniformly have as one of their highest level aims to provide an excellent/second to none/great quality of life for their citizens and businesses. In fact, many strategic transport policies also express similar high level aspirations, seeing mobility and accessibility provided by the transport system as one of the key elements to achieve the desired quality of life. UDS's also include a broad spectrum of objectives which relate, in generic groupings, to environmental, cultural, social and economic desires. Most objectives do not relate directly to transport matters, although given the inter-related nature of a city system, few would not be affected by nor affect the transport system in some manner.

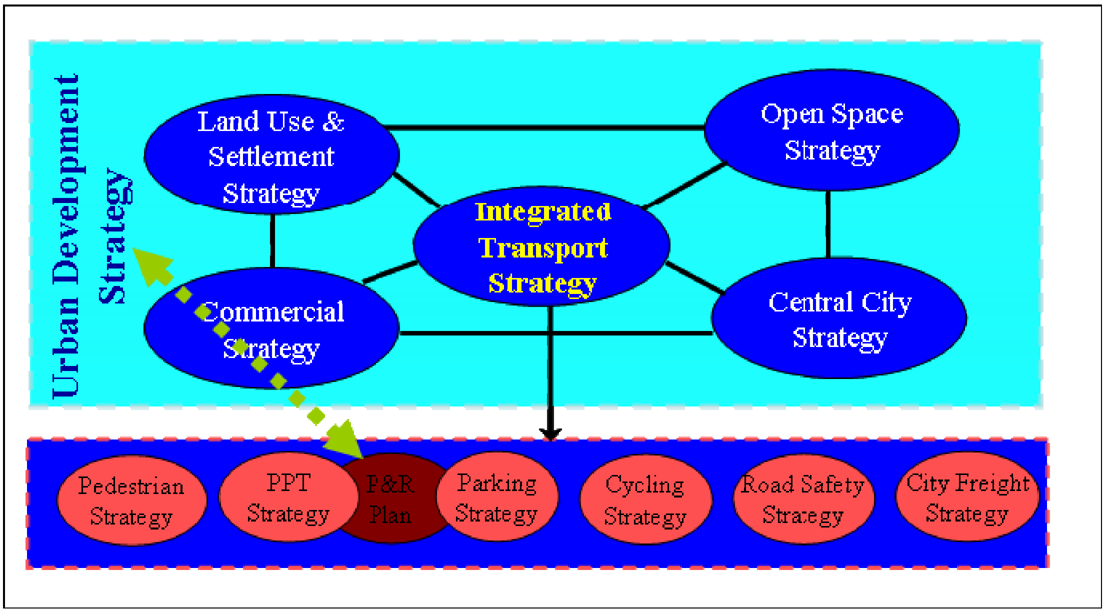
However, there is significant debate at community, political, professional and academic levels related to the directions, assumptions and content of the UDS's. This is more than the diversity of philosophy between the supporters of "market-forces" and "interventionism", but also within each grouping regarding detail of implementing the policy. Unfortunately, there is surprisingly little hard data and useful research to inform the debates well, perhaps as there are so many variables to consider – cultural, geographical, historical, environmental to name a few, and consequently no two cities are the same. In addition, as is well recognised, gathering data and information is an expensive exercise even in relatively small settings, and hence at the large scale required to inform urban form strategic debate, it is difficult to acquire the necessary or needed data and information in sufficient amounts. This then reduces the debate to largely theorising and personal/professional opinion, with many assumptions unable to be confirmed or set aside. However, one issue generally agreed upon across the planning philosophy spectrum is that there is a need to try to enable holistic decision-making, considering all (or as wide as possible) issues affected by decisions.

This does however lead to the conclusion that it is often not clear what the best way forward is for developing and implementing Urban Development Strategies, and that the linkages between the component parts are not well understood. Nevertheless, this does lead to a view that there is clearly a potential for transport strategies (or individual component parts or projects, such as Park and Ride systems) to conflict with the land use development strategies. Notwithstanding, this research project is assuming the development and existence of Urban Development Strategies and transport planning strategies for cities.

This project will examine Park and Ride systems as a particular potential element of transport strategies which may or may not conflict with land use development strategies (see Figure 1.1).

A preliminary literature review has shown that there is limited knowledge in the assessment of Park and Ride systems from a strategic perspective, let alone the interaction between Park and Ride systems and any associated Urban Development Strategy. This research project will address the linkages between Park and Ride as a policy tool and urban development or desired future urban forms. Therefore a broad aim of this research project is to begin to reduce the uncertainty and lack of knowledge in this particular relationship. All the preceding comments do however lead to a view that as the matters are so complex, yet at the same time have relatively little information available, the greatest challenge for this project is to be able to create a meaningful, simple and useful framework.

Figure 1.1 Relationship between Urban Development Strategy and Park & Ride Strategy



Strategic land use planning is a very broad topic, as is strategic transport planning. This project will only start to scratch the surface of a particular aspect of where these two topics meet. The topic will not deal with operational issues which are already well covered in literature and professional experience around the world. It is not known whether there is any other directly similar research which has been undertaken on this topic, but a preliminary literature review suggests not.

It is recognised that many factors affect the success of Park and Ride systems (however that may be defined), but this research project is not seeking to identify and quantify those relationships. These factors include matters such as level of vehicle ownership, cultural views of the private motor car, the quality of the existing public transport system (including relative trip time between car-borne and bus based travel), density of population, legal and administrative structures, and the generalised cost of trip-making. This project will focus on exploring the provision of an assessment framework that can provide information on the best Park and Ride system classification (or ranking thereof) for a given urban form, assuming that the other factors would not affect the choice of type within that urban form.

The scientific problem for this project is the study of the relationships and interactions between Park and Ride systems and different types of urban form, which will be principally demonstrated through a predictive framework that will seek to indicate which, and to what degree, Park and Ride systems support various desired urban forms.

1.2 Motivation

Transport plays an increasingly important role in growing cities, especially when operating under tight financial or economic conditions. The transport system of an urban area can support or compromise quality of life of the citizens and businesses. Quality of life is a common goal (at the strategic level) for transport system strategies as well as for the government and agencies which deliver the systems and oversee the development of urban areas in general. The adverse effects of transport systems are well known and include, amongst other matters, use of valuable land, inefficient energy consumption, congestion, adverse emissions to air, requirement for large amounts of funding, crashes, community severance, and run off of pollutants to waterways.

If an urban area wants to create a realistic vision for its future development and growth, it must look to integrate its transport system development. This includes all aspects, such as major roads and key corridors, support for active mode infrastructure, pricing, etc, as well as any public transport and Park and Ride systems.

The study of the interaction between land use/urban form and public transport/transit has been a focus of much attention for the past 15-20 years (Cervero & Seskin, 1995). This has resulted from a number of pressures and challenges in the planning both of urban forms and their associated transport systems (Auckland Regional Growth Forum (ARGF), 1999).

Two key challenges in particular that are driving a need for better research on the public transport/land use linkages are the apparent inability of public transport to enlarge its mode share in new world cities in spite of significant investment in public transport; and authorities planning to further expand and invest in public transport need better information on the land use densities and mixes of uses that could support and enhance system success (Cervero & Seskin, 1995).

Whilst much has been written on the public transport/land use linkages issue, most has been theoretical or hypothetical, and little by way of empirical studies has been reported. As few as a dozen empirical studies have been conducted on this matter over a 30 year period (1965-1995) (Cervero and Seskin, 1995). As Park and Ride is in many ways a subset of public transport, it is apparent that there is very little related to the interactions between Park and Ride systems and Urban Form.

However, literature abounds with reports and papers both supporting and raising doubts and challenges about the benefits and effects of Park and Ride systems (Office of Deputy Prime Minister (UK), 2004; Hamblin, 2005; Public Transport Users Association, 2005).

It is usual for transport planning funds to be at a premium. Therefore decisions related to how to invest in the transport system need to be made wisely, with good information and analysis to support them. Authorities cannot afford to waste scarce funds, and need robust analysis to support applications for them. Furthermore, implementation of a transport strategy component, such as Park and Ride, that fails to produce desired outcomes (or visibly fails to attract patronage) may irreparably damage the potential implementation of other public transport initiatives (or other components of the strategy) that may better contribute to the objectives of a strategic development plan.

In New Zealand, Christchurch (through a joint forum of authorities) is currently pursuing the creation of an Urban Development Strategy. Christchurch City Council also has resolutions to investigate Park and Ride proposals, such as that below. There are similar resolutions and expressions of interest in these investigations from Environment Canterbury and Waimakariri District Council.

> *"That a study be initiated to explore opportunities for bus priority measures and develop a proposal for 'Park N Ride' in the study area, in conjunction with Environment Canterbury, and reported back to both Councils."*
> *(Christchurch City Council, June 2003)*

The Christchurch City Council needs to ensure, as far as possible, that these two initiatives support one another. However, as noted above, there is little information on the linkages between them and there is a need to learn from and develop what little there is.

This research project will assist in addressing the questions that arise in situations such as Christchurch about whether Park and Ride systems are necessarily a good thing, and can they support or, perhaps more importantly, obstruct the achievement of the objectives of an urban area's strategic development plan. A specific concern in the Christchurch situation is whether Park and Ride systems promote urban sprawl, or do some types of park and ride systems tend to more so than others? It is worth noting that this research project is not seeking to conclude whether Park and Ride systems would be successful in various situations, but rather should one be desired, what would be the optimal or ranked order of system types to support the urban areas objectives.

So, to maximise our chances of achieving our overall goals of excellent quality of life, we need to improve our understanding of the interactions and outcomes of Park and Ride (or any other transport initiative) as they affect Urban Development Strategies or urban form evolution. This will allow better decisions as to whether and if so, how, Christchurch should pursue a Park and Ride system.

1.3 Objectives

This research project intends to analyse the interactions and linkages between the policy decisions related to Park and Ride systems and Urban Growth Strategies, and to propose a predictive framework that would enable the identification of the most suitable type of Park and Ride scheme (from an identified classification list) for metropolitan land use development strategies or for supporting desired urban forms.

The specific objectives of this research are to:

- Review Park and Ride systems and research from a range of countries to identify from a strategic perspective how a range of Park and Ride systems are operated and to collate associated research and monitoring information;
- Present a proposed classification scheme of Park and Ride systems, with related information, objectives and data;
- Outline a range of urban development forms, with associated objectives;
- Assess how various Park and Ride systems meet their objectives under the generic urban form classifications;
- Assess how various Park and Ride system types impact on or contribute to the achievement of the objectives of the generic urban forms in the classification system;
- Propose an Assessment Framework as a predictive tool which is simple, robust, reliable and understandable;
- Verify using real world examples and experience whether the framework reflects real world results; and
- Use the framework as a predictive tool to identify the optimal Park and Ride scheme type(s) for use and integration with the likely land use development strategy for Christchurch, New Zealand.

Thus the fundamental objective of this project is to develop a predictive framework which may assist in identifying Park and Ride system types that may support various desired urban forms.

This research project challenges the presumption that Park and Ride is unilaterally effective in achieving the many objectives often ascribed to it.

1.4 Research Method

This research project is largely a literature and desk top analysis exercise, rather than physically testing and/or undertaking base measurement/data collection of outputs of scenarios constructed to test a hypothesis. Therefore the method is based around an initial research and review stage to assess whether anything of relevance exists in currently available literature and information on the topic. This also includes discussions with a number of experts in the fields of park and ride, and strategic land use planning in New Zealand. From the findings of the review stage, an analytical framework is proposed aimed at enabling the assessment of the effects of Park and Ride on Urban Development Strategies. This is then to be verified by testing the framework against real world examples where information exists and refinements made from the information derived from this verification process. An attempt will be made to apply the framework to some generic simulated urban areas to evaluate its predictive ability by way of sensibility checks on the outputs, and then it will be applied to the Christchurch situation to propose which category of Park and Ride system would appear to suit the desired future urban form of the city.

The research structure (illustrated in Figure 1.2) will involve 5 stages.

Stage 1. Literature Review and Information Gathering:

- Review what Park and Ride systems and Urban Development Strategies (UDS) are, as well as what has been or is being done in New Zealand and around the world. Included will be assessment of the UDS's as expressed in District Plans and any implied urban form considerations or explicit relevant policies in Regional Land Transport Strategies;
- Establish what has already been reported on how Park and Ride systems and Urban Development Strategies interact or affect each other;

- Investigate whether there are established classification systems or “types” of park and ride systems and generic land use patterns, and assess to identify typical associated objectives and outcomes of each; and
- Investigate whether there are similar cities to Christchurch that have Park and Ride schemes.

Stage 2. Analytical Framework:

- Seek to create an analytical framework or conceptual model to assess the implications of Park and Ride systems on Urban Development Strategies. This will likely be based on multi-criteria analysis;
- Methods of “scoring” or filling in the multi-criteria matrices in the framework will be considered, along with issues of weighting and dealing with unlike attributes. From this a preferred scoring methodology will be identified for this project.

Stage 3. Assessing the analytical framework:

- Verify the analytical framework using information and the experiences of cities with Park and Ride schemes to refine and assess the analytical framework. This will seek to include information from national sources, such as Auckland and Wellington, as well as international sources, principally from UK, US and Australia;
- This stage may iterate with stage two.

Stage 4. Case Studies:

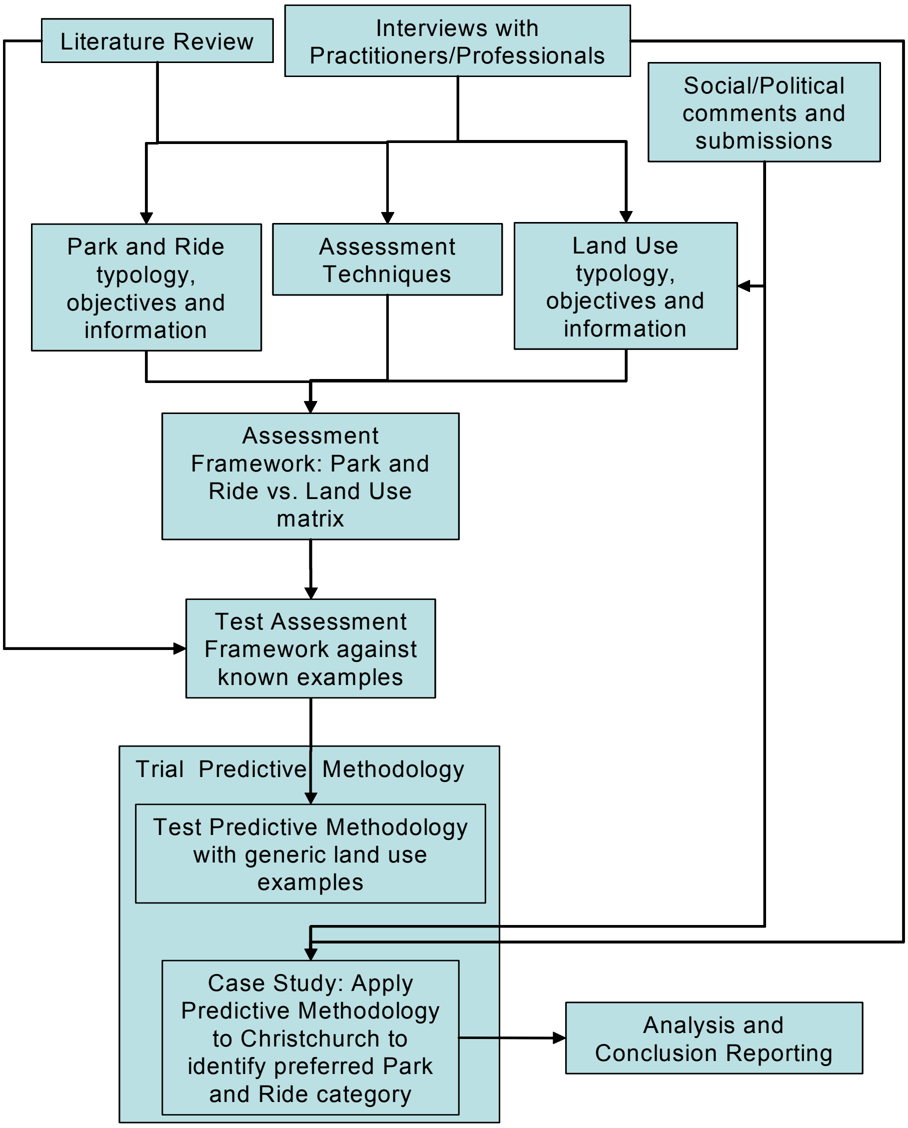
- Apply the framework to a small number of generic, simulated urban areas, to evaluate its predictive capacity; and
- Apply the framework in a predictive manner to identify the most suitable Park and Ride scheme classification(s) for Christchurch. This is the principal purpose and desired outcome of this research.

Stage 5. Analysis, Conclusions and Dissemination of Findings:

- Collate all previous sections prepared;
- Write up the case studies, assessments and conclusions;
- Present findings to Council forums of staff and elected members;

- Present findings in a progress seminar at a time to be determined during the project development; and
- Undertake a Christchurch City Council (CCC) and other Territorial Local Authority staff peer review process.

Figure 1.2 Proposed structure of project development



1.5 Structure of the Study

The structure of this research report is based on 7 chapters, including this initial chapter outlining the project's objectives, method, motivation and structure.

Chapter two provides an overview of the findings of the literature research undertaken on this topic, covering Park and Ride system policy, system descriptions, system reviews, multi-criteria analysis, and urban form analysis, review and theory.

Chapter three proposes an Assessment Framework that is based on 2 classification systems (one for urban forms and the other for Park and Ride systems). The key components of the Assessment Framework are a matrix using the classification systems as the two axes, with an analysis spreadsheet underpinning each cell in the matrix. The remainder of the chapter deals with using the matrix, assessing the initial results in the matrix, and documenting the sensitivity tests carried out along with observations regarding the strengths and weaknesses of the Assessment Framework.

Chapter four tests this Assessment Framework against some real world data, to assess its validity and gain understanding and insights into potential improvements.

Chapter five again tests the Assessment Framework, but this time against some generic urban forms with synthetically generated information.

Chapter six then applies the Assessment Framework as a predictive tool to the Christchurch, New Zealand situation, given the likely preferred urban form to be promoted through its development work on an Urban Development Strategy.

Chapter seven then draws some conclusions and summarises the project, looking at the process, the Assessment Framework with its usefulness and weaknesses, potential improvements and the proposal for Christchurch along with discussion on the confidence with which Christchurch could move forward with the recommended outcome. A range of potential further work and research is also outlined in this chapter.

Chapter 2 Literature Review and the current New Zealand Situation

2.1 Introduction

A literature review has been conducted to gather and assess scientific data, information and analysis to acquire an understanding of Park and Ride in other cities and countries, as well as to establish and understand what previous research and investigations have been conducted.

As this research project topic is so broad in its focus, it is reliant upon information in other research and studies, rather than generating original source data as its primary input. The literature review is therefore the key input in the methodology of this project.

The literature research has searched for views, reviews, data and information relating to Park and Ride systems, Park and Ride as a policy tool and the justification of Park and Ride systems when implemented and supported as a continuing service. Most information on Park and Ride systems has been sourced from 4 countries: United Kingdom (UK), United States of America (US), Australia and New Zealand, with some information also found from Asia. Similarly an investigation of urban form literature and New Zealand's recent strategic urban form studies has been conducted to identify key forms, objectives and performance information.

Further information has been found through interviews with a number of key New Zealand practitioners in the areas covered by this study, particularly public transport planning, strategic transport planning and strategic land use planning. Some additional information available and known to the author through work contacts has been sourced to provide additional context and research for this project.

The information presented below is intended to provide a summary of the relevant and key information, developments, views and assessments discovered to date.

2.2 Park and Ride

This section describes what Park and Ride is, reviews systems from around the world, considers the purposes and objectives of Park and Ride systems, examines what previous analyses have been conducted and presents some of the criticisms levelled at Park and Ride.

2.2.1 Description

Park and Ride, as an element of the transport system, is usually seen as an extension of the central area parking stock, connected between the parking site and the central area by a (high quality) public transport service (Parkhurst, 2000). The public transport service may be either provided by rail or bus, and this research will focus primarily on the bus-based option although relevant rail-based Park and Ride information is included where considered useful. Park and Ride therefore attempts to provide a blend of the benefits of car travel and public transport travel for different parts of a journey.

Often the main objective of Park and Ride systems is to relocate parking demand (and therefore the attendant travel) from the busy central area to a remote site (EHTF, 2000; IHT, 2005). A range of objectives for Park and Ride systems are presented in section 2.2.3 below.

Some park and ride systems have also developed into a park and (carpool) ride system, wherein the parking station becomes the collection point for those choosing to car-pool from that point onwards in their journey. This may become increasingly frequent as high occupancy lanes become more frequent across the transport network (Transport Research Board (TRB), 2005).

2.2.2 Review of systems

The review of Park and Ride systems undertaken for this project has focussed on the United Kingdom, United States, Australia and New Zealand, with some limited information being found for parts of Asia and mainland Europe.

The following sub-sections summarise the characteristics of Park and Ride systems in various countries. Comments will be based on findings by country, although comments on the New Zealand situation will be provided in section 2.3 New Zealand Current Practice, Experience and Vision of Park and Ride".

A. United Kingdom

Park and Ride systems have, over recent years, received significant support from the UK central government, and there has over the past 15 years been a major expansion of the number of park and ride systems across the UK. These systems are principally bus-based systems, but rail-based and tram-based systems are also present.

The most common systems are the bus-based Park and Ride systems, with a range of parking stations located on the periphery of a town or city. Most systems still only have a very small number of parking stations, but some are now getting a full suite of sites around the urban edge with some 5-7 sites. Each site usually has a capacity of several hundred parking spaces and some are close to 1000, resulting in some systems providing a total of many thousands of spaces (5000+ in Cambridge, 4000 in Norwich).

In addition, these systems usually have dedicated bus services operating between the parking station and the town centre at relatively high frequencies (<10 minutes during peaks, and about 15 minutes off-peak). There is only one Park and Ride station on each service, so the buses shuttle between a specific station and the central city stops only. The park and ride bus services are usually not consciously integrated with the wider public transport system of that area. The systems are run by the local Council (County, City or sometimes both), with, in some instances, sponsorship by local businesses.

The information in the following paragraphs provide detail of specific UK systems, which have been derived from city and county council websites as well as conference papers from the UK. Providing this level of detail gives an opportunity to develop an understanding of the magnitude of systems and how common the style of implementation and operation is across the UK.

The purpose of most UK systems is to try and capture traffic travelling into the town centre from surrounding areas outside the urban area, and to a lesser extent some trips of the townspeople living near the periphery stations. In some instances the Saturday usage is in fact higher than the weekday patronage (for example, Oxford between 1992 and 1999). Thus the stations are generally located adjacent to the key access roads and arterials entering the urban area (such as Cambridge, Oxford, Norwich, Nottingham and York). They do not appear to have a unique purpose of targeting commuter travel, as most operate 6 or 7 days per week.

Oxford is in an unusual situation where the City Council and County Council each operate separate Park and Ride sites (about 4 County and 2 City parking stations). It appears that the City sites may be integrated with and support the wider bus system. It is interesting to note that in the monitoring research undertaken in Oxford by the County Council (2002), one County site had a shift in patronage numbers to a new lower level (about 1600 vehicles /day in 1998 to about 1200 vehicles/day in 2001) when the general bus services in the surrounding area were substantially improved. That research indicated that the patronage loss for the Park and Ride scheme was transferred to the improved bus services, indicating that these passengers were now travelling their whole journey by bus. With Oxford being a very well established public transport market, it is suggested that this level of transfer is relatively higher than less established markets, as passengers are more comfortable and selective with their choice of bus travel.

Shrewsbury, a small historic town (population c.100,000), has stated aims for its Park and Ride to improve the accessibility of Shrewsbury for people in ways that do not increase dependence on the private car, and to make Shrewsbury as safe as possible in ways which respect and enhance its historic character. This small town has three Park and Ride sites, providing 1992 parking spaces. It operates a 10 minute frequency bus service with super-low floor buses, and presently carries some 3-5% of visitors to the town centre (compares to 45-50% by car) (Surl, 2005). In surveys of trip purpose of users, it has shown that over 60% of Park and Ride trips are for shopping purposes, and around 20% each for tourism and work/commuting. Research is also showing that whilst usage is relatively inelastic to the fares charged, as the fares have increased over the past 5 years and are now approaching the cost of parking centrally, the patronage is clearly declining albeit slowly (one can only speculate regarding the potential growth that this system would have had if the fares-to-parking charges ratio had been kept constant at the level of the late 1990's). In addition, there has been an increase in central city parking supply, with a major mall redevelopment occurring in the core area. A key message from their research was that people will use Park and Ride if they believe that it is cheap and convenient.

A number of cities in the UK have also re-introduced tram (light rail) lines in recent years, and integral with the development of these tram lines have been associated Park and Ride systems. These are arranged differently to the bus-based systems noted above, in that they are set up more like rail-based, corridor-focussed Park and Ride systems with a number of parking stations along the route. This can be seen in the tram systems in Nottingham (the NET with 4 parking stations) and in Sheffield (the Super Tram).

Heavy rail-based Park and Ride also exists in many locations throughout the UK (for example Glasgow, Edinburgh, Manchester, Sheffield and London). Sheffield has Park and Ride operating on 3 rail lines coming into its city centre, although the parking facilities do not provide large amounts of parking (line one with 7 stations and 160+ spaces, line two with 6 stations and 320+ spaces, and line three with 3 stations and 170+ spaces).

B. United States

Park and Ride in the USA appears to be primarily an adjunct to the general bus-based public transport system and involving little public agency input other than basic co-ordination of information. It is based on developing databases of existing parking facilities made available for Park and Ride purposes, which are close to a public transport service. These facilities range from church car parks and shopping centre car parks to works yards. An agency or consortium, such as a Department of Transport or public transport commission, appears to take ownership of developing and maintaining the parking facility database and listing it for public access. As an example, in Connecticut, the Department of Transport lists some 230 sites across the state for parking associated with both bus and rail public transport services, with site sizes listed from 20 to 1000 spaces (ConnDOT, 2006).

Similarly, the Metropolitan Transport Commission and Bay Area Transportation Partners in San Francisco list some 150 sites providing parking facilities to access the Bay Area Rapid Transit system or bus services, with capacities between 10 and 3245 spaces (511 Rideshare, 2006). TriMet in Portland, Oregon also promote Park and Ride sites on a public database to access its MAXX tram, light rail and bus services (TriMet, 2006).

In all cases, the sites are scattered across metropolitan and town areas, and provide informal parking opportunities with otherwise "normal" use of the public transport system (both all-stops and express services). All the sites reviewed also noted that the parking facilities could be used for congregating areas/meeting points for carpools and vanpools. In the vast majority of locations the parking is free. The responsible agency may provide some limited services for the Park and Ride system, such as formal signage noting that the site is a Park and Ride site or support some form of site maintenance or security. Many sites have requested limitations on use, such as churches requesting week-day only use.

There are also systems operating which may be considered a type of Park and Ride, which are also termed "Peripheral Parking" (TRB, 2003). These locate the publicly-provided parking stations on the periphery of the central business district. "*Such facilities are generally sufficiently removed from the downtown core proper that they can be inexpensively priced, yet close enough that their users can either walk to their final destination or take a short bus ride, often a shuttle*" (TRB, 2003). The private sector has been encouraged to develop these in some jurisdictions through planning/development incentives, but very few have been developed and developers are generally reluctant to be involved. This "collar" type arrangement of Park and Ride system was introduced as a demonstration project in many US cities in the 1970's and 1980's, and is still operating, such as Cincinnati (Ohio), Cleveland (Ohio), San Diego, Albany (New York), Pittsburgh and Atlanta.

The rail-based park and ride provision in the USA operates at another order of magnitude to US bus-based or UK rail-based Park and Ride systems. Supporting the Boston light rail and metro system are some 14,000 parking spaces and for the Washington metro there are over 20,000 parking spaces. Over the border in Toronto (Canada), there are some 18,000 parking spaces mostly on its commuter rail lines.

C. Australia

Australia does not appear to have the same focus and emphasis on Park and Ride as does either the UK or the USA. Park and Ride is operated in association with both rail-based and bus-based public transport. No permanent general bus-based park and ride with dedicated bus services was found in the research conducted for Australia.

- ***Rail-based and Bus Rapid Transit Park and Ride***

  Rail-based Park and Ride is evident in Melbourne and Perth, the two cities with the most extensive and developed rail based public transport systems in Australia. In both cities, the Park and Ride systems are based along the rail corridors, with in some cases significant parking sites provided at the stations (e.g. five stations on the 29 km Currambine line (Perth) with five stations is one of four similar lines. Its Warwick station alone has over 1000 spaces. There are many stations on the Frankston line on the Mornington Peninsula in Melbourne). It also appears that the transport planners have envisaged specific roles for the various rail stations/interchanges, given comments such as "*Currambine station was specifically designed to capture park and ride passengers from these more northerly suburbs rather than have them drive into the regional centre at Joondalup to catch the train*" and "*Joondalup, not Currambine, is the designated bus/rail interchange.*" (both quotes from Ker & Ginn, 2003)

The Belconnen to City transit-way is one of five transit-way proposals for Canberra by the Australian Capital Territories Planning and Land Authority (ACTPLA). This is a proposed 7 km two-way, two lane bus-only road connecting north-west suburbs with the central city area, via a number of major attractors (e.g. Canberra Stadium, hospital and two Universities). It is still being consulted upon and hence not yet operational. This transit-way is planned to operate as a Bus Rapid Transit (BRT) system, and has park and ride stations proposed along its length. However little could be found regarding the detail of the park and ride facilities and operation proposed. Consultation material simply notes “the provision of park and ride facilities allowing residents to park outside the City and catch a high speed bus into the City” (ACTPLA, 2006).

- ***Central city mobility services***

Park and Ride as promoted by Melbourne City Council (the council covering a very central area of Melbourne) involves enabling all-day parking at Melbourne Museum or Telstra Dome for a set fee which then also allows all day tram travel within the central city area. The system operates Monday to Friday only. Telstra Dome is located at the western edge of the central city, with reasonable access from a motorway, but is also immediately adjacent to Spencer Street rail station, one of the 3 main central city rail stations. The Museum is located on the north-east corner of the central city. Both locations are on the city circle tram line amongst many others.

- ***Event or seasonal specific services***

Bus-based Park and Ride appears to be used in Australia as a traffic management measure for major events. These are special purpose initiatives for particular events, such as Australia Day or major sporting events. The Wollongong City Council operated a Park and Ride system for the 2006 Australia Day celebrations as part of the traffic management to maintain accessibility to central areas which had large areas closed off to general traffic for the day. This was provided free, presumably funded as part of the event promotional costs. The North Queensland

Cowboys Rugby League Club promotes Park and Ride as a means of access to their (Dairyfarmers) stadium for home games. The bus ride has a fare, and the parking is permitted at a range of hotels, shopping centres and parks in the surrounding suburbs.

The City of Greater Geelong Council operates what is called a Park and Ride system in its central city area. This involves a free central city only bus service routed specifically to pass within walking distance of some 20 central off-street parking facilities. Thus drivers can park their vehicles at (nominally) secure off-street car parks and use the bus as a shuttle service around the central area. This service has been operated since 1999 between late November and early February each year, as a summer and Christmas service, to assist in dealing with the greater transport demand on central areas during the peak season.

2.2.3 Purposes and Objectives

Park and Ride systems can help promote sustainable travel patterns at local and strategic levels (ODPM, 2000) and have been seen as a cheaper alternative to road building for addressing congestion (Council for the Protection of Rural England (CPRE), 1998). In addition, they can have the maintenance of or increase in numbers of economically-desirable trips to a city centre or other key destination as a key aim (Parkhurst, 1996). These have, in many countries, been prime purposes for implementing Park and Ride schemes. It has also been popular from being "seen to be green" as a transport system development option by many people (CPRE, 1998).

A further key purpose of Park and Ride is to address the poor use of large amounts of space that parking takes in high value areas, which is costly to business and reduces the densities of more valuable activities in those centres. If parking can be provided remote to these high land value areas, then a better economic and environmental outcome can be achieved for that centre. This has led to the situation where Park and Ride systems are "*particularly popular in historic towns and cities such as Oxford and York (UK), where the opportunity to provide extra parking in the centre is often limited by the need to preserve historic buildings and street patterns*" (CPRE, 1998).

Many transport planning agencies also have related (sometimes conflicting) policy goals that parking policy should not create incentives for businesses to relocate away from town centres (ODPM, 2000).

Park and Ride systems can also be introduced with a purpose of increasing the potential catchment population for the main public transport services of a town or city. It can be more economic to introduce a Park and Ride system than extending the existing public transport system (with the same service quality) into the more remote and/or lower density catchment areas (which are always difficult to service well by public transport) (ODPM, 2000). An example of this is the Delaware Department of Transport (DelDOT) which considers that Park and Ride lots are special types of bus stops intended to extend the reach of transit (public transport) by collecting passengers from a wider area (DelDoT, 2000). That view indicates that the purpose of Park and Ride is to concentrate transit users from low density areas and areas which cannot be directly served by transit vehicles, thereby maximising the efficiency of the transport system by using each mode in its most efficient manner.

Park and Ride systems can be developed on temporary bases with a prime purpose to enable access to occasional/special events (IHT, 2005), and this has been seen in system examples in the previous section.

Notwithstanding the above paragraphs, it has been the experience in at least the UK that there has been some confusion regarding the actual objectives and purposes of Park and Rides schemes as they are planned and implemented (CPRE, 1998). Alternatively, "*local authorities may not always have understood that there are different and sometimes mutually-exclusive justifications for P&R*" and "*some authorities have perceived that P&R systems can give achievable benefits without being excessively demanding in terms of resources*" (Parkhurst, 1996). In addition, it appears that the objectives of schemes can change over time, with researchers noting that "*local authorities have not considered the full range of impacts of their P&R schemes and their rhetoric has sometimes reflected changed policy goals in a context of unchanged practical measures*" (Parkhurst, 1996)

Various researchers and transport agencies have proposed lists of objectives for Park and Ride systems, as noted in Table 2.1 below. They have been grouped into four generic areas, in line with research (Parkhurst, 1996) that there are four nominal types of objectives which Park and Ride systems seek to achieve: economic, transport, social and environmental. Many of the "social" type objectives appear to duplicate those in the economic or transport groups and have been allocated there. However some cannot and therefore justify the inclusion of the social grouping itself.

Clearly some of the listed objectives are closely related, and a reduced set of key objectives is possible to identify. Such a simplified set of objectives is proposed in Table 3.4.

2.2.4 Previous analyses and monitoring

Analysis and reviews of the success of Park and Ride schemes have increased over recent years. Previously there has been a simplistic view that if the parking spaces are full, there are well used buses from the Park and Ride and there is less congestion in the town centre then the Park and Ride system must be a success (Hamblin, 2005). In another paper (CPRE, 1998), a similar telling reflection is made – "*If you measure 'success' of Park and Ride schemes in terms of the level of usage, then many of them are a success. Only recently, however, have researchers started to ask more difficult questions as to whether they have delivered the expected environmental benefits.*" In neither case, nor in literature generally, is the measure of success linked to "value-for-money" (or economic efficiency).

Many researchers have found that there has not been much genuine research into the success of Park and Ride schemes, especially in terms of whether or not they meet their objectives (the original objectives or those which may have subsequently evolved). Comments have been made that "*there is a difficulty in uncovering useful data to examine the effects of P&R in any analytical detail*" (Parkhurst, 1996) and "*there is a lack of 'before' and 'after' data which could establish the degree of success in transportation and environmental terms*" (CPRE, 1998).

Table 2.1: Park and Ride System Objectives

Objective Type	Objective	VTPI[1]	Booz Allen & Hamilton[1]	Parkhurst[1]	TRL[1]	TRB[1]	IHT[1]	Anon.[1]
Economic	Reduce the amount of parking required in the CBD/ improve land use efficiency in CBD		✓	✓	✓	✓	✓	✓
Economic	Reduce commute travel times							✓
Economic	Improve city centre accessibility			✓			✓	
Economic	Enable traditional commercial centres to compete with car-oriented retail developments			✓				
Economic	Increase the number of economically desirable trips to a city centre			✓				
Economic	More cost-effective provision of parking for central city	✓		✓				
Economic	Provide for parking types normally discouraged from central city (e.g. commuter cars)						✓	
Economic	More economically efficient transport system	✓		✓		✓		✓
Transport	Reduce traffic levels on urban radial routes		✓				✓	
Transport	Reduce congestion levels on urban radial routes	✓	✓		✓			✓
Transport	Reduce traffic levels in the CBD itself		✓		✓	✓		
Transport	Reduce congestion levels in the CBD itself	✓	✓	✓		✓		✓
Transport	Reduce the need/pressure for increased road capacity	✓	✓					
Transport	Reduce car use			✓	✓			
Transport	Reduce total traffic	✓				✓		✓
Transport	Reduce peak period traffic	✓					✓	
Transport	Increase ridesharing	✓						
Transport	Increase public transport use	✓				✓		✓
Transport	Increase cycling/walking	✓				✓		✓
Transport	Easier parking to find & use							✓
Transport	Improve road safety	✓						
Transport	Improve quality of motorist's journey/less driving stress			✓				✓
Environ-mental	Reduce local emissions/ pollution levels	✓	✓	✓		✓		✓
Environ-mental	Reduce transport greenhouse production	✓		✓		✓		
Environ-mental	Reduce energy use		✓					
Environ-mental	Reduce other environmental impacts (e.g. noise)	✓	✓	✓				
Social	Increase social inclusion/community liveability	✓		✓				

1 VTPI (2005), Booz Allen & Hamilton (1999), Parkhurst (1996, 2000, 2005), TRL (2005), TRB (2004), IHT (2005), Anon (post 2000)

In relation to specific issues, comments relate to "*the available (economic-effects related) evidence is mainly of an anecdotal and intuitive nature and restricted to the effects on the host urban area*" and "*there is a lack of empirical evidence about the direct effects of park and ride on air pollution*." (Parkhurst, 2000) However, this issue is slowly changing through research being undertaken since the late 1990's.

A key difficulty that appears to have impeded good research and data collection is that the Park and Ride schemes are generally implemented in a piecemeal fashion over a number of years, making the decision to assess them during that time difficult with methodological issues of individual, short term and cumulative effects, and other changes in the transport system clouding investigation proposals. In addition, the issue is compounded by the difficulty of whether variables are potentially correlated or truly independent, such as increased patronage may be the result of the Park and Ride system or from other factors which made the destination significantly more attractive. The political perspective also has an influence, in that once established as a full system, there has been so much investment in the system that any shadow of doubt potentially being cast over that investment is not welcomed (it is more politically expedient to promote that having full car parking stations and full Park and Ride buses means that the Park and Ride system must be a success).

The following summarises some of the limited analysis and reviews that have been published related to Park and Ride systems, based on experiences in the UK (largely edge of urban area schemes, operated independent of the general public transport system) and in the USA (largely informal and unplanned, but centrally promoted parking sites).

Park and Ride systems can accommodate traffic growth through redistributing it to the periphery of an urban area whilst allowing more people to access a central business district, bringing more customer business to that centre (CPRE, 1998). Studies have shown that people visit the town centres more often (3-9%) and are attracted there (2-8%) from other previous destinations, and that drivers would travel further to access a Park and Ride site in deference to driving through congested traffic congestions (CPRE, 1998 and Parkhurst, 1996).

It is accepted that well designed and operated systems can increase public transport patronage and can reduce vehicle travel on the road network, but a key input to this is the location and distribution of parking stations.

However, it is also accepted that Park and Ride can potentially exacerbate congestion in the area surrounding the parking stations (wherever they are located). In a similar fashion, it has been found that while Park and Ride schemes may reduce town centre traffic, they may also increase urban fringe traffic, as motorists detour (sometimes considerable distances) to reach parking stations or make more trips to use the system more often (VTPI, 2005).

There is little definitive evidence that Park and Ride systems reduce congestion beyond the immediate area of the public transport destination and even then it may not (Anon). Other work considering congestion has conclusions regarding "*the ineffectiveness of P&R in reducing traffic downstream of the sites. No long-term reductions in traffic levels have been attributed to the P&R schemes considered in this review*" (Parkhurst, 1996), and edge of urban area Park and Ride schemes have "*been associated with more, not less, car travel*" (Parkhurst, 2000). Given this background, it could be concluded that if congestion relief was the primary purpose of introducing Park and Ride schemes, then they would have been abandoned long ago.

Cambridge's (UK) Park and Ride system also shows little evidence of reduced traffic or congestion (Lucas-Smith, 2000). This has been ascribed to the City Council refusing to implement an agreed integrated transport policy, which included central traffic demand restraint measures, and has refused to remove central city parking. The outcome of the introduction of the Cambridge Park and Ride system is that it resulted in simply having more parking, leading to more traffic overall. A consequential effect was that subsidy levels were high at £1.06 per return journey, which created an uneven playing field for the city's existing public transport services. That led to the cancellation of marginal public transport services, leading to an increase in social exclusion. A key criticism made by the Lucas-Smith study was that it appeared that the Cambridge Park and Ride system caters for car drivers' needs rather than trying to change travel behaviour. However, a more recent commentary

(TRL, 2005) noted that Cambridge had, since Lucas-Smith's review, made town centre parking more expensive and reduced the supply, making it more convenient and cheaper to use Park and Ride. Unfortunately no comment was made on the effect of this new situation regarding parking provision.

UK experience, where Park and Ride bus services tend to be independent of the town or city's public transport system, is that there can be significant competition between the two systems, with Park and Ride taking passengers away from the wider public transport system.

US figures show that some 40-60% of new Park and Ride passengers were formerly drivers of single occupant cars (Anon). The same study indicated that in a Chicago study it was found that three new passengers (from other modes or induced trips) were attracted to that Park and Ride system for every former bus passenger. UK experience reported is that about 55-65% of Park and Ride passengers had previously driven to the city centre, with about 20-40% abstracted from the existing public transport system (Parkhurst, 1996 and CPRE, 1998). It is also considered that Park and Ride can enhance an existing public transport system if carefully designed for new users, through careful planning of fares, routes, excellent accessibility to existing bus stops and quality of buses in the two systems (TRL, 2005).

Whether the Park and Ride system is integrated with the wider public transport system or operates an independent bus service, research indicates that there is an ongoing need to provide public subsidy to operate the systems (CPRE, 1998 and VTPI, 2005). However, this could potentially be justified on the basis of the subsidy enabling higher consumer spending in the destination town centre (Parkhurst, 1996).

Some discussion has occurred considering why Park and Ride schemes are normally not achieving their proposed congestion relief nor the public transport objectives. Park and Ride is clearly a supply side policy option for transport system development. Therefore, unless carefully implemented, it is likely to do little to reduce overall traffic levels where there is any form of suppressed demand, or demand is sensitive to generalised cost of travel, as it simply reduces the overall cost of travel and frees up opportunity and space for others to travel.

In addition, Park and Ride schemes have in many instances been implemented in an environment of conflicting transportation policy. Whilst the introduction of the Park and Ride schemes may have had certain objectives, at the same time parking was not reduced or made more expensive at the destination end (resulting in the Park and Ride parking operating effectively as additional satellite parking, creating more trips or induced traffic), wider roads were being built, and the system was not integrated with the wider public transport system operations.

Another possible reason for the lack of congestion relief associated with Park and Ride schemes is the small scale of the systems. As an example, in a developed western city with a population of some 300,000 residents, which has some 150,000+ vehicle movements crossing into the central city every day, a system with 5,000 parking spaces (as big as many UK systems) will hardly have a noticeable effect on the traffic stream (e.g. 65% abstraction from cars * 5000 = 3250 trips, which represents some 2% change, less than the daily variation in traffic and less than a years growth).

A further potential reason relates to the focus of the Park and Ride operation, as some systems are focussed on or perform better for shopper trips (travelling predominantly in non-peak hour periods) rather than focussing on peak hour commuting trips. Services not focussed on peak hour commuter travel are likely to have only nominal impacts on congestion, which is typically a peak hour phenomenon.

With particular regard to the Park and Ride systems based on peripheral parking stations (close to the city centre), research has shown that in these systems where parking stations are within 1.5 kms of the central city,

> "*a substantial number of peripheral parkers were found to choose walking for the final leg of their trip, rather than transit service. Although the expected short-haul transit ridership did not materialize in these cases, shifts in parking demand and traffic away from core areas was nevertheless achieved*" (TRB, 2003).

Despite this dynamic, literature (TRB, 2003) suggests that peripheral parking stations may also take away patronage from local public transport services. In addition, the research on these systems highlighted that whilst there were examples of successful and failed systems, a key issue determining the outcomes was the level of "*user cost savings over core area parking to justify the extra time or inconvenience incurred*" (TRB, 2003). This was related to the situation that

> "*users of peripheral lots do not have the opportunity to avoid congestion on routes leading to the CBD or to significantly decrease vehicle operating costs, leaving downtown parking saturation and cost as the primary inducements to park in peripheral lots"* (TRB, 2003).

This matter of "user cost savings" can easily be applied in principle to all Park and Ride systems.

Strong views have been expressed regarding the need for integrated implementation, such as

> "*if there is no package of significant traffic restraint measures to mitigate, then the decision to adopt P&R should perhaps not be made on transport grounds. If the implementation of P&R is considered for economic reasons, then the local authority should be prepared to account for the corollary environmental dis-benefits*" (Parkhurst, 1996)

Analysis of the Houston (Texas) Park and Ride system revealed a minute reduction in air emissions. This result was tied to a nominal reduction in vehicle distance travelled and the relative impact (inefficiency) of vehicle engine cold starts and short trip making. As vehicle emissions are affected by such a variety of factors, it is not possible to conclusively state that Park and Ride will cause an increase or reduction in vehicle emissions, and differing Park and Ride formats may well tend to different results according to vehicle distance travelled in various levels of congestion. Nevertheless, whilst city-wide emissions may not change much, local air quality may very considerably, according to any changes in local traffic volumes and congestion levels. It is however, questionable whether monitoring could ever discern enough to be able to apportion air quality improvements/deterioration to initiatives such as Park and Ride, given all the background variables which affect air quality (Parkhurst, 1996).

In line with concerns about the lack of impact on congestion reduction and the observed increase in vehicle distance travelled, studies have indicated that

> "*an 'energy audit' of P&R schemes implemented so far would show net environmental costs due to the lack of a 'decongestion dividend' inside the city coupled with an increase in vehicle-kilometres travelled outside as a result of increased trip-making and transfer from public transport services*" (Parkhurst, 1996).

This may have been a reflection on the type and detail of the Park and Ride schemes analysed, as other work has indicated that there may be "modest reductions" in energy use (VTPI, 2005).

As noted above, the location and distribution of the parking stations is critical to the success of a Park and Ride system. In summary, the key principles found are that the average (total) trip length should be at least 4 miles (7 kms) (Anon), although there are some notable exceptions such as Melbourne. Placing a park-and-ride station too close to a destination reduces it to a satellite parking facility for the destination that will have little potential impact on regional traffic congestion or air quality as nearly all the trip will still be by car and unless parking is very constrained in the centre, few would accept the transfer penalty so close to their destination. Therefore the site must be far enough out to make mode change worthwhile, e.g. 2-4 miles and a 10-15 minute bus ride (Anon and TRL, 2005). It appears that established facilities in the UK are based on a short-range bus service (typically 4 km radius, and somewhere between 2 and 5 km), and involving longer car-legs of the journey (Chester – 25 km, Oxford – 20 km and York – 13 km) (Parkhurst, 1996 & 2000). Placing the parking stations too far away will increase pressures toward urban sprawl without encouraging more transit use.

In addition to distance from the final destination, the location of the parking stations should ideally be placed just prior to the car/private vehicle travel encountering a major bottleneck or congestion point, especially if the bus service is able to bypass this point through some sort of priority measure (Booz-Allen & Hamilton, 1999).

A very important characteristic of the destination for Park and Ride systems is that car use is optional at it (Anon); that is, visitors do not need cars to conduct their business or activities at the destination. For example, if the Park and Ride drop-off facility/terminus in the central business district is separated from the final destination by a considerable distance or is located in a vast car park area, the walk-ability to the final destination will be reduced and the attractiveness of that final destination similarly reduced.

In addition, UK and USA studies have raised concerns that if Park and Ride schemes were implemented with no other policy controls, they may result (over a longer term) in lower density development in the immediate vicinity of the car parking station (ODPM, 2000). This would compromise any desire to pursue Transit Orientated Development initiatives using the Park and Ride station as part of the development node. "*If the parking facility presents a barrier to access from surrounding neighbourhoods, it can reduce the likelihood of transit-oriented development and may also reduce the benefits of any development that does occur*" (Anon). However, the same studies have noted that easy access to secondary destinations (such as shopping or day care facilities) at a parking station can improve utility of the facility to potential users. It has been reported that "*shopping centres adjacent to Park and Ride facilities tend to benefit from additional shopping by the commuters who park there*" (VTPI, 2005)

The case for whether Park and Ride schemes have reduced the pressure for decentralisation of activities or consumption for parking of sensitive or valuable land elsewhere is neither apparent nor measurable (Parkhurst, 1996).

A strong case which has been made by some researchers, although yet to be confirmed by data, is that Park and Ride systems may create or enable urban sprawl through increased or cheaper mobility. The net travel time and cost from more remote (and rural) areas may be reduced enough to create an incentive for further sprawl (Anon). Even if the urban sprawl is not considered, it has been noted that in considering Park and Ride station development "*the potential consequence of encouraging more commuting from rural areas needs to be addressed*" (IHT, 2005).

This all highlights the need to ensure that if wider objectives are to be achieved, it is vital that the Park and Ride system is part of an integrated transport policy which is implemented (CPRE, 1998). This is acknowledged in official UK government reports wherein

> "*Park and Ride needs to be examined carefully in terms of what it is hoped to achieve. It is not in itself a panacea and is much more likely to succeed if introduced as part of a comprehensive transport strategy*" (Pickett and Gray, 1996)

This is reinforced through a number of independent UK studies which note that

> "*the efficacy of particular policies (such as Park and Ride) is fundamentally determined by interaction with complimentary policies*" and
>
> "*Park and Ride should not be introduced too soon during the transition to a restraint policy*" (both Parkhurst, 1996)

With the above results of Park and Ride schemes in mind, some researchers have suggested that Park and Ride schemes should be seen as an interim solution, as they do not eliminate car dependency, but instead make it easier to achieve environmentally beneficial policies. In this light, Park and Ride would be seen as a "*necessary half-way measure to get car owners to think about switching to public transport*" (CPRE, 1998). In the USA, a similar conclusion has been proposed that Park and Ride fills "*the gap between solely automotive and transit based transportation*" and is thus an effective transition strategy to move people from the car to the bus (Anon). In this context, the role of Park and Ride itself may be rather minor or even counter-productive as a traffic diversion measure, but a greater purpose may be served by its existence.

Although there is a considerable body of literature related to Park and Ride systems, little has been presented on objective based analysis of the systems. Neither has there been much attempt to classify systems. Only one paper has been discovered (Young-Jon, post 1999) that attempts to create any classification system associated with Park and Ride, and that sought to classify the Park and Ride stations in the Seoul Park and Ride system. That classification system simply allocated the stations into one of three categories according to distance from the Seoul central city (less than 15 km, between 15 and 25 km, and greater than 25 km). No papers or research have been discovered which attempt to deal with categorising entire systems at the strategic level.

2.2.5 Criticisms of Park and Ride Systems

As much as Park and Ride is a popular transport initiative amongst many organisations (political, community and lobby groups), it also has many detractors and those who are cynical of its worth.

The key criticisms of Park and Ride are based around the following eight themes and can be grouped as driven by one or more of three motivations (extreme environmental perspectives believing anything related to cars is bad; strong pro-road perspectives desiring the funds to be spent on roads instead; and economic critiques viewing Park and Ride as failing to meet economic efficiency objectives):

- Space required for parking in high cost areas or high amenity areas
- Lack of impact on congestion
- Lack of integration with wider transport system, particularly the public transport system
- Increased car usage, and the knock-on effect of additional road building to get the car drivers to the park and ride sites
- Social issues related to the requirement to still own and use a car to access public transport
- Increased air pollution/emissions
- Concern about from where its patronage is drawn
- Access to public transport should not need to rely upon or promote car-based access

Parking sites in high cost or high amenity areas

Dealing with each of these in turn, the amount of land required for the parking sites often generates the key concern from critics of a scheme. This can either be concern regarding the land consumption in areas of environmental sensitivity, which is often the UK issue, or requirement for significant areas of high cost land in the midst of high density activity areas if linked with transit-oriented developments (for example, around a commercial centre focused on a railway station).

In Melbourne's situation, some 20% of rail users access the system by using the Park and Ride facilities at the rail stations, yet authorities continue to spend large sums expanding the parking facilities in deference to improving feeder bus services (Public Transport Users Association (PTUA), 2005). With Melbourne having an urban form based in many areas around the rail stations, a clear example of the high cost of parking being developed is a recent expansion of the parking site at Huntingdale at which the government spent $2 million adding 120 spaces (averaging Aus$17,000 each – nearly NZ$20,000, which is slightly in excess of the cost paid per space by Christchurch City Council to provide multi-storey parking facilities in Christchurch, but at Huntingdale there are no parking charges to recover the costs). Not only is this expensive parking, it also removes opportunities for other higher value development activities within this urban centre, as integrated developments providing mixed use (parking and other commercial/business activities on the same site) are the exception rather than the rule.

The use of land for parking is often criticised for the adverse visual and amenity effects of the sites. This occurs whether or not the land is used for general parking or park and ride parking sites. It also can occur both in an urban area or a rural/natural setting, although usually more stringently so in the latter case. Whilst there is dissatisfaction with "the acres of car parking" surrounding Melbourne rail stations, the visual/amenity issues are where the UK critics often level their most strong objections to Park and Ride proposals as the sites are often located in the green belt or peri-urban areas of towns and cities (CPRE, 1998).

Lack of impact on congestion

Parkhouse (2000) in his extensive reviews of Park and Ride systems (particularly focussed in the UK) has noted that he has yet to find a Park and Ride system which has relieved congestion, despite this often being an initial objective and justification of developing and continuing such systems.

For Melbourne, it has been shown through the Australian census that only some 20% of rail commuters access the station by car. Thus Park and Ride as an adjunct to that public transport system (rail in this case) is used by a minority of users. Given that about 5% of Melbournians use the train, even doubling the use of Park and Ride would have only about a 1% change in mode split with a very high associated cost (PTUA, 2005).

Lack of integration with wider transport system, particularly the public transport system

In most urban areas with Park and Ride systems, the Park and Ride system was promoted and implemented as part of an integrated transport package which had an overall aim of reducing amount of travel by car, especially in the central business district. The key common failing is that whereas the Park and Ride system provides an improvement to the transport system supply, the complementary restraint measures, such as parking controls or constraining car access to sensitive areas, have not been implemented. So the original transport package is compromised and will never deliver the aims it was seeking to achieve.

One of the ironies of this situation is that a common justification of the Park and Ride system is that it is promoting use of the public transport system to encourage less use of cars, but at the same time requires ownership of at least as many cars as if there were no Park and Ride system in place.

This situation adds weight to criticisms of Park and Ride systems by such groups as CPRE, which raise the challenge (based on the UK Government's PPG 13 policy) that, in creating a transport package, has Park and Ride been shown to be an essential element or could the packages' aims be achieved in other more effective and less environmentally damaging ways?

The financial set-up of the Park and Ride systems does not appear to consider its implications on the wider public transport system (CPRE, 1998). Issues exist regarding the relative subsidy levels required of the public transport system and the Park and Ride system (i.e. which provides the best outcome per subsidy dollar/pound?), and the relative fares and charges to the users. Park and Ride systems tend to attract comparatively large subsidies, and this inequity can lead to the cancellation of marginal bus services with the consequential increase in social exclusion, especially for those who do not have a car to access the Park and Ride system (Lucas-Smith, 2000). Is it therefore reasonable to charge higher fares for Park and Ride users as their system costs more to provide, or should the fares be equal despite the imbalance of subsidies this would create especially in the differing level of public transport service and facilities provided? These issues are especially highlighted where the services operate in the same corridors (or at least draw from the same catchment).

Concern about from where its patronage is drawn

It is often assumed that the patronage of new Park and Ride systems will be drawn from car drivers (and perhaps their passengers) who see the Park and Ride option as preferable to using their car for their whole journey. However, system data does not show that this is necessarily the case.

In Doncaster, Melbourne, a review by the Department of Infrastructure of a recently developed "successful" Park and Ride station installed in 2002 found almost no new public transport users. All others had previously caught the bus for their entire journey. A primary reason for such a strong pattern was that the Park and Ride station was just inside a major fare boundary, so it was cheaper to drive to a free car park for all day and catch the bus for a cheaper fare (PTUA, 2005).

UK studies (CPRE, 1998) have shown that 20-40% of Park and Ride users previously used the existing public transport system. This is a considerable abstraction from the public transport system, and changes the financial viability of the pre-existing bus services.

Increased car usage

Encouraging Park and Ride use can result in more cars travelling in the vicinity of the Park and Ride stations. Whilst there may be a relief in congestion in other parts of the network (but see above comments on congestion relief), this can create congested conditions around and on the approaches to the Park and Ride stations, leading to calls for road upgrades. This leads to the perverse situation where to support Park and Ride (and a better public transport) system, more roads are needed to support the car drivers access to the Park and Ride system. It also leads to what appear to be confused statements by politicians, as shown by two quotes from Australia (PTUA, 2005):

> *"Mayor Sam Alessi said that the (major roading) upgrade would result in more people using public transport ... and the extension is needed to get people to where the transport is."*
> from "Road Hope in Sight", Whittlesea Leader, Whittlesea, 27 July 2005, and
>
> *"The cost of petrol has increased the demand for public transport. We must improve parking."*
> Cr. Brian Oates (City of Casey), Cranbourne Leader, Melbourne, 5 October 2005

The requirement to still own and use a car to access public transport

There is also criticism of Park and Ride from a social policy perspective. Park and Ride systems still require users to own a car to make the Park and Ride trip, which provides a bias against those who do not own or have access to a car for whatever reason. In addition, with the car being left at the station all day (in the case of commuters), others in their household then do not have access to that car and may require other cars for their trip requirements (perhaps another park and ride trip!).

Increased air pollution/emissions

As Park and Ride systems can result in increased numbers of trips and vehicle-kms, then the associated effect of increased emissions to air from the vehicles may occur. In addition, a further effect relates to many of these car trips being of a short duration and length. Short trips result in a greater proportion of the trip being undertaken with the engine running cold compared to longer trips, so even if the vehicle-kms remains similar (from more but shorter trips being made), the engines are operating less efficiently overall and thus contribute disproportionately to air emissions and pollution. (PTUA, 2005)

Access to public transport should not need to rely upon or promote car-based access

This criticism is most applicable in the relatively uncommon cases where there is no general public transport service in an urban area except the Park and Ride system, or where a rail-based commuter service operates with no (or poor) supporting feeder bus services. In these situations, the public transport routing structure is so sparse that the only realistic way for most users to access it is by car. This unsatisfactory public transport service provision also creates the perverse situation whereby there may be demands to increase road capacity along congested car routes on the way to the public transport interchange/parking station.

Overview of the Criticisms

The criticisms are quite valid in many cases (as demonstrated in the above comments) and many examples to support them can be found. However, if the criticisms are considered carefully in the set-up and operation of Park and Ride systems, there is little doubt that they can be largely mitigated, if not avoided all together. For example, the Park and Ride stations could be located away from high intensity/high value urban nodes, they can be designed sensitively with the surrounding land forms and they can be well integrated with the wider public transport system (such as fare boundaries in relation to the Doncaster, Melbourne example above).

2.3 New Zealand Current Practice, Experience and Vision of Park and Ride

This section will examine the current situation related to Park and Ride systems in Auckland, Wellington and Christchurch, and in particular deal with existing practice, plans and policies, practitioner perceptions and the associated current issues and challenges. Information in this section related to Wellington's situation is principally derived from an interview (Wellington, 13 February 2006) with Tony Brennand (General Manager, Greater Wellington Regional Council) and Kevin Grace (Transport Infrastructure Co-ordinator, Greater Wellington Regional Council), and for Christchurch from an interview (Christchurch, 3 May 2006) with Matthew Noon (Strategic Planner (Operations), Environment Canterbury). Information for Auckland has been derived from interviews with Auckland Regional Transport Authority and Transit Busway Project team members (Auckland, November 2005), consultant reports and media releases.

2.3.1 Plans, Practices and Visions

Wellington has historically had the most developed and recognised Park and Ride network in New Zealand. It is developed and managed by Greater Wellington (Wellington Regional Council), largely focussed around the 4 rail lines on the Kapiti Coast and Hutt Valley corridors. There are currently some 40 Park and Ride parking sites based around the rail stations, with a total stock of about 4000 spaces. The larger sites are Waterloo with 600 spaces and Paraparaumu with 400 spaces. Park and Ride at Wellington's rail stations is very well patronised, and extends to informal use of surrounding streets at some stations. Wellington also has a bus-based park and ride site in Karori, serving the bus services from west Wellington suburbs.

Greater Wellington is considering extending the electrification of the commuter rail services on the Kapiti Coast rail line up to Raumati. Part of the early planning is considering the provision of Park and Ride facilities through early purchase of land near to the stations with the proposed improved services, as well as transit-oriented development opportunities.

Auckland has for many years had a scattering of park and ride facilities across the city and its public transport catchment areas. These parking stations support rail, bus and ferry based public transport services. The bus-based sites had generally been modest sized parking areas between about 10 and 40 spaces, located variously throughout North Shore, Waitakere, east Auckland and Manukau. Rail-based stations, located in Waitakere and Manukau, varied significantly in size with about 15 at Waitakere through to some 200 at Papakura. The ferry-based Park and Ride stations vary in size from about 30 in Northcote to over 150 in Devonport, servicing the ferries operating between the central city and North Shore or Waiheke Island (Booz-Allen & Hamilton, 1998).

More recently, Auckland has opened the first elements of its Bus Rapid Transit (BRT) system, which runs between North Shore (Albany) and the central city (Britomart), predominantly within the Northern Motorway corridor. This system operates major Park and Ride stations at key interchange points along the Motorway, with two currently operating at Albany and Constellation Drive. These two stations provide over 700 spaces collectively and have been full with excess cars parking in surrounding streets since opening in November 2005. This was reduced from original plans, in which 1500 spaces were proposed at the Constellation site alone. All parking spaces are usually occupied by 8.30 a.m., indicating a very strong commuter demand for the system and making it difficult to assess the potential inter-peak demand. Some 2100 bus boardings per day are currently reported in the system, although clearly not all passengers are accessing the system by car, with feeder bus services, walking and cycling also being used.

Buses will continue to use the dedicated bus lanes on the motorway shoulder until early 2008, when the separated bus-way lanes and the final three stations (at Sunnynook, Westlake and Akoranga), which form the rest of the Northern Busway project, will open for use. Initial investigations are underway exploring the option of introducing parking stations around Orewa (Rodney District) to the north.

2.3.2 Practitioner's perceptions of Park and Ride

Greater Wellington very clearly sees Park and Ride as an integral component of the region's public transport system. Their philosophy revolves around making public transport as attractive as possible, by making the total journey attractive (including the non-public transport elements).

With its geography promoting urban corridors and a strong central city focus, public transport systems are able to provide good levels of service to the Greater Wellington community. As public transport is successful in meeting its objectives and in playing a key role in Wellington's transport system, Greater Wellington is intending to continue supporting public transport including Park and Ride. There are ongoing plans to continue expanding the Park and Ride system with a focus on trying to actively meet the growing demand (in a prioritised manner given funding constraints). Related enhancement plans are to improve lighting and security at the existing Park and Ride sites.

Greater Wellington's planners see further potential for integrating the parking stock for Park and Ride with other activities in the vicinity of stations, in shared parking arrangements. A current example is at the Johnsonville Station, which is adjacent to the Johnsonville Mall. Parking for rail passengers is permitted in the wider Mall car park by agreement, with both parties seeing benefits of saved capital costs and better exposure of their activity to users of the other.

In Auckland, there appears to be general practitioner support for Park and Ride systems for all modal options (bus, rail and ferry), as part of the overall mix of measures to try and address the Auckland transport situation. There is considerable support and enthusiasm for the recently developed BRT system, especially with its considerable early success in filling to capacity the currently provided parking stations. However, there is considerable uncertainty as to what the actual demand is, both generally (e.g. its total quantum) or specifically (e.g. types of users, origins of users, previous mode used). Therefore there is support for undertaking investigations to clarify many of the unknowns before beginning any significant planning to expand the system beyond completing its currently planned facilities.

2.3.3 Regional Land Transport Strategies and Urban Development Strategies

The Wellington Regional Land Transport Strategy (WRLTS) has a strong policy position of continuing to enable public transport as a major mode and continuous improvement of the public transport system. As noted above, there is a strong focus on providing a high quality total journey experience, to promote use of public transport.

The Wellington Regional Policy Statement is currently under review, but indications are that it will provide stronger direction on urban development and urban form strategies to cater for the growing population in the Wellington region. A new urban development document (tentatively the "Wellington Regional Strategy") is anticipated to be produced in June 2006.

The Auckland Regional Land Transport Strategy recognises the existence and encourages the further development of Park and Ride facilities across the city for both bus-based and rail-based Park and Ride. It promotes Park and Ride through policies related to accessibility, wherein more sustainable modes of travel are encouraged with Park and Ride facilities to be introduced and promoted in support of that, and corridor development, wherein the capacity of corridors may be increased through the provision and promotion of Park and Ride facilities.

2.3.4 Issues, Challenges and Barriers

As seems typical worldwide, Wellington has undertaken little in terms of research and monitoring of the Park and Ride system from a strategic and objectives-achievement perspective. Park and Ride was included in the Wellington regional computer-based transport model, so some observed data has been captured. An overview of the analysis of this data has been produced for the Wellington Regional Land Transport Committee in 2001-02. Limited indicator information is available in the Annual Monitoring Report of the WRLTS.

The key issues for Auckland to continue developing its Park and Ride system are gaining better understanding of the markets being served and gaining funding for new facilities from road controlling authorities and from Land Transport New Zealand. Another, albeit operational, issue for Auckland is integrated ticketing between operators of the public transport system, to enable better interchanging between services.

2.3.5 Park and Ride in Christchurch, NZ

Christchurch currently has no formal Park and Ride system. Whilst little actual planning has been done to progress Park and Ride in Christchurch, it has significant political interest (and nominal support) from City and Regional Councillors. It appears that this interest is largely based on Park and Ride being a novel measure for Christchurch (with significant expectations of its ability to impact on congestion, and a perception that central city congestion is caused by commuting travel from adjacent rural districts to the north and south west of the city), and it is a relatively easy measure to implement (compared to some transport infrastructure projects or demand restraint options). Successful introduction of a park and ride system would enable the Councils to show that they are actively doing something intended to address congestion. This interest has generally been much more muted amongst elected officials of the adjacent Waimakariri and Selwyn districts.

In Christchurch, congestion is growing on the arterial road network, affecting all travellers. There are priority corridors under planning for public transport which are intended to mitigate the effects of the congestion on the public transport system and to act as an encouragement for increasing patronage from abstraction of car drivers and passengers. Park and Ride is seen as a complementary measure, allowing some ongoing use of cars for a part of a journey, with the transfer to bus in areas where it is desirable to avoid congestion.

There are a range of ideas in the community and amongst elected officials in Christchurch as to where and how Park and Ride should be developed. The main concept is bus-based, with stations positioned variously at:

- (for the northern corridor) the north end of Cranford Street, near the Belfast Supacenta, at the Tram Road interchange (Ohoka area) and the Lineside Road interchange on the northern motorway; and/or
- (for the south-eastern corridor) near McCormacks Bay; and/or
- (for the south-western corridor) at Lincoln, Templeton and Rolleston, linking to the new Hornby interchange; and/or
- very close in to the central city, adjacent to the Four Avenues.

Recent metro service contract reviews in Waimakariri District have shown a resistance to any proposals suggested to interchange between proposed bus services at the south end of the district to a high frequency/high quality bus service into Christchurch, and no desire to have increased rates introduced to pay for such a proposal.

Christchurch does have informal Park and Ride operating, with travellers parking their cars at key locations on the bus system and catching the bus onward. The main area that this is occurring is in relation to the Diamond Harbour Ferry, with locals driving from townships on the south side of Lyttelton Harbour to the Diamond Harbour Ferry wharf area, catching the ferry across to Lyttelton and catching the No. 28 Metro service into Christchurch. The ferry car parks are overflowing (with public pressure now resulting in Council plans to expand them) and the ferry service is oversubscribed during peak hour. This informal Park and Ride is also occurring:

- at Church Corner (with people travelling in from west townships such as Kirwee or Darfield and catching a bus to the central city or Riccarton; or city residents catching a bus out to Lincoln from Church Corner;
- around the south end of Papanui Road, with people driving to that point and catching a bus into to town (this was more prevalent when short-distance bus fares existed for that distance); and
- people from in or around Tai Tapu drive into Halswell to catch the bus into town.

The Canterbury Regional Policy Statement is pitched at a high strategic level, and has very few specific statements or measures included. As a consequence, it is not surprising that there is no specific reference in this document to the place of Park and Ride schemes in Canterbury. The Canterbury Regional Land Transport Strategy also makes no strong statements regarding Park and Ride. It is mentioned in the Strategy's Goals and as an option in three methods related to integration of bus-based public transport with other modes, future development of rail-based passenger transport and considerations for future land-use/transport planning. Given the lack of specific focus or investigation that exists around Park and Ride in Canterbury, it is unsurprising that there is no clarity regarding any key issues or objectives for Park and Ride, such as who should lead the implementation and operation, who it would be targeting, would it operate only certain hours or days, or would it be integral with the Metro bus system?

If Christchurch is to implement a Park and Ride system, its key challenge is to clearly articulate its objectives. As the main reason currently cited by most proponents suggesting Park and Ride in Christchurch is congestion relief, then an integrated transport strategy needs implementing that includes the significant complementary restriction or reduction in attractiveness to park in the central city area or any other destination areas that the scheme is serving (and that is likely to be extremely controversial).

This leads to probably the key barrier to introducing a “successful” Park and Ride system in Christchurch: that is the strong car culture which exists and generates strong protectionist reactions (often supported by many key decision-makers) when challenges to unfettered car-based travel are raised.

In Christchurch, a concern has been expressed amongst transport planners regarding the competitive behaviour that occurs in many UK Park and Ride systems between the Park and Ride operation and the wider public transport system. There is the view that any proposed Park and Ride system for Christchurch must fully integrate with the metro bus system.

For Christchurch, a further issue relates to some people at the adjoining rural Councils appearing to hold an attitude that Park and Ride is solving a city issue and why should rural ratepayers pay for the set-up and ongoing operation of a scheme that benefits the city areas. This ignores that the rural ratepayers impose costs within the city, and would benefit from enhanced accessibility offered by the Park and Ride system. Given that a Park and Ride system in Christchurch is likely to need the cooperation of a number of transport agencies, this may be another key challenge, although the key agencies (Environment Canterbury, Christchurch City Council and Transit NZ) are all supportive in principle of travel demand measures such as Park and Ride.

2.4 Urban Land Use Forms

This section provides background material related to one of the two key planning fields that are the focus of this research project; that is, land use planning and research that has been developed around urban form classification.

2.4.1 Land Use Planning

Cities and towns may be defined as "*a locational arrangement of activities or land-use pattern, where the location of activities affects human beings and human activities modify locational arrangements*." (Khisty, 1990) Similarly, cities and towns have been described as being of fundamental importance as places of economic production, transport/distribution and exchange (Pacione, 2001).

Whilst the urban form of a town or city is strongly influenced by its physical geography, it also strongly reflects the needs of resident individuals, communities and local business/commerce. As these needs change through time (which can most easily be traced through an area's social or economic history), so to does the urban and political form. These needs are also heavily influenced by, and dependent upon, available technology (e.g. transport, manufacturing or communications technology) (Pacione, 2001).

Urban form is the overall pattern of land uses in an urban area, which can be considered an aggregation of individual decisions of land owners and developers (Chapin, 1957). It is also defined as

> "*the spatial pattern or arrangement of individual elements such as buildings, streets, parks, and other land uses (collectively termed the built environment), as well as social groups, economic activities, and public institutions within the urban area*" (Khisty, 1990).

This pattern may or may not have occurred within a context of overarching planning controls or conscious direction of authorities, which may be identified as land use planning.

The development and ongoing growth-associated changes to urban form has brought many benefits to their communities (which collectively exceed the costs) as well as many problems. Amongst the problems are that most, if not all, cities experience traffic congestion and increasingly, in car-dominated transport systems, social equity issues related to accessibility to social needs (employment, education, health care, etc.) occur.

There has been a long standing debate as to whether land use planning should occur, and, if it is attempted, whether it is effective in achieving its objectives or provides an efficient outcome (Banister, 1997; Pacione, 2001).

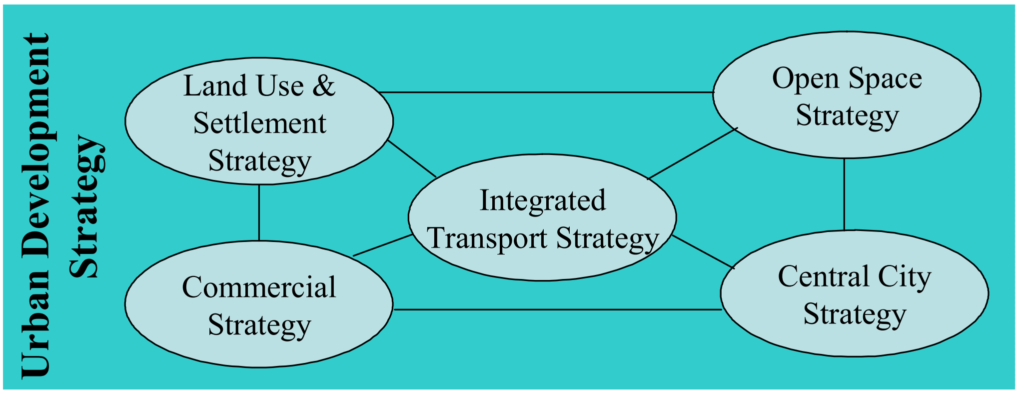
Notwithstanding this issue, land use planning occurs in some form in most if not all developed countries and over time is having increasing effect on the urban form of the city or town to which it applies.

Land use planning, as with all planning activities, may occur within a hierarchy of levels, from national perspectives through regional or comprehensive planning and district planning to individual site or minor policy issues. The basis of planning at all levels is a structured process of identifying objectives for achievement (or problems to avoid) and choosing amongst alternatives the best mechanism(s) or conditions to meet the planning goals.

Within general land use planning at the metropolitan or urban area level, the general theme is to improve the future so that the town or city is a great/better place to work, live, recreate and invest in ("*a better physical living environment*" – Chapin, 1957). Subsequent planning that contributes to or influences the urban development, such as developing the transport system, should be done so to accomplish and maintain the overarching goals.

In New Zealand over the past decade there has been a recent trend to produce Urban Development Strategies. These exist for Auckland and the Bay of Plenty, and are being created for Christchurch and Wellington. Urban Development Strategies in this context focus primarily on physical planning with a particular concern to deal with population growth (and associated infrastructural needs, costs and effects). Urban Development Strategies or Urban Form Plans cover a wide range of urban interactions and systems, such as the location and distribution of housing and commercial activities, provision and operation of open space, and promotion of special purpose areas (e.g. Central City) in addition to the transport or other network systems. Furthermore, some such as Wellington also explicitly attend to associated economic matters such as economic development. Figure 2.1, which shows the basis of the initial planning for the Greater Christchurch Urban Development Strategy, indicates the types of issues addressed and their inter-relationships. A key issue in these strategies is the recognition of the interactions and relationships between all component parts.

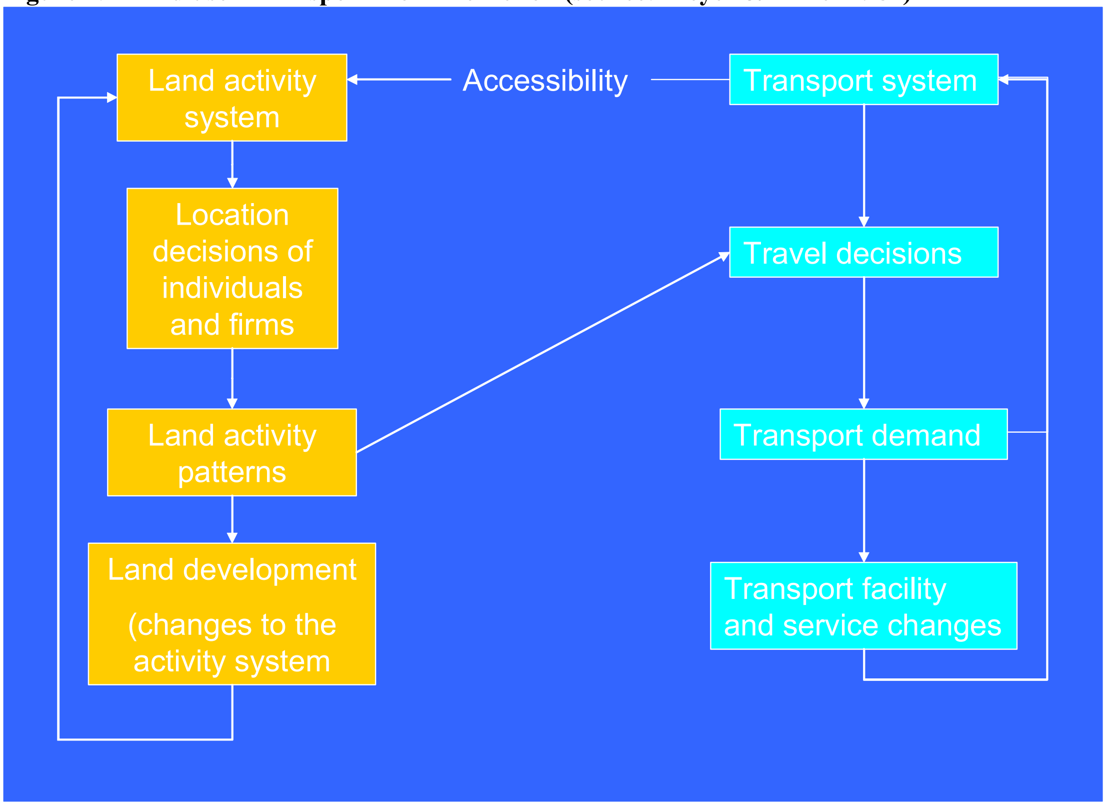
Figure 2.1 Elements of Urban Development Strategies



A fundamental influence on transport systems are the urban forms in which they operate and serve. There is a two-way relationship between land use development and the transport system in which they are functions of each other, with land use influencing the transport system operation, and the transport system operation influencing the land use system. For the transport system, trip distribution, trip demands and mode choices are strongly affected (indeed are driven) by land use activity and distribution. Similarly for the land use system, distribution and intensity of uses are influenced by accessibility, safety, reliability and mobility provided by the transport system (Meyer and Miller, 1984). Figure 2.2 outlines the relationship.

In summary the land activity system (costs, planning environment, resource availability, etc.) influences the location decisions of individuals and businesses which then create the patterns of activity associated with the location and functions of the land uses. These patterns generate travel needs and decisions, which lead to transport demand. The transport demands operate within the transport system (infrastructure, costs, legal environment, etc.), which impacts on (and is impacted on by) travel choices and also result in the accessibility provided for the land activity system. This system can operate in equilibrium, but there are opportunities indicated by the bottom boxes on both sides of the figure, which indicate changes to either the land activity system or the transport infrastructure or services. These create changes to the dynamic of the relationship shown in the upper part of the figure, which operates in a temporary unstable system whilst seeking to return to an equilibrium situation again. In reality, there are constant changes occurring as represented by the lower 2 boxes, and as a consequence, the upper relationships are constantly adjusting and seeking an elusive equilibrium (perhaps able to be described as a dynamic equilibrium, with the system in a constant state of flux and seeking an ever changing equilibrium point).

Figure 2.2 Land use - Transportation interaction (source: Meyer & Miller 1984)



An element not indicated in Figure 2.2 is that of the time dimension in terms of the response time for the various dynamics to occur. It has been noted that the results of planning activities and decisions are discernible only 5 to 20 years afterwards, making feedback and corrective actions difficult (Feldt, 1988). The response time relates to the level at which any analysis occurs. For example at the micro level, it can be relatively short. This can be seen with a new development on a particular site can create significantly changed demands or a new bus service can open up the accessibility of an employment area.

At the macro-scale (city-wide), this can be quite long term, as the existing systems of land use activity and transport supply which tend to dominate (or swamp the effects of) individual changes (and are generally a sustained collection of smaller individual changes over time), tend to take a long time to achieve because of the length of time for developers to collectively recognise, respond to and take advantage of the opportunities, and the length of time it takes to deliver major publicly-provided infrastructure on a metropolitan scale. An example is the lead time to deliver Christchurch's Southern Motorway which has been identified for over 30 years and is still at least 6 years from opening.

However, given the issue of the magnitude of existing activity systems and infrastructure being so dominant in relation to individual changes, it does not appear clear whether "*incremental improvements in this access (increased supply from introducing Park and Ride) can alone affect metropolitan patterns of urban development.*" (Meyer and Miller, 1984) Notwithstanding this, Meyer and Miller also go on to note that

> "*it has become apparent that, although the overall regional impact of new investments in transportation facilities on urban structure is often negligible, the* ***distributional*** *impact on new development* ***within*** *a region can be substantial, given the right circumstances*."

So there would appear to be a view that whilst issues such as Park and Ride may not fundamentally influence the rate and nature of development of an urban area, they may still influence distribution of the land use activity system of the urban area (and may depend to some degree on what other activities co-locate around the Park and Ride facilities).

Given the above and for the purposes of this project, a land use/urban form category will be proposed to allow exploration of the interaction of the various Park and Ride classifications in differing urban settings.

2.4.2 Overview of Classical Urban Land Use Form Descriptions

Over time, geographers and land use planners have proposed a range of descriptions and models to explain the urban forms of towns and cities. A few are outlined below, indicating a general development of these models and the associated thinking.

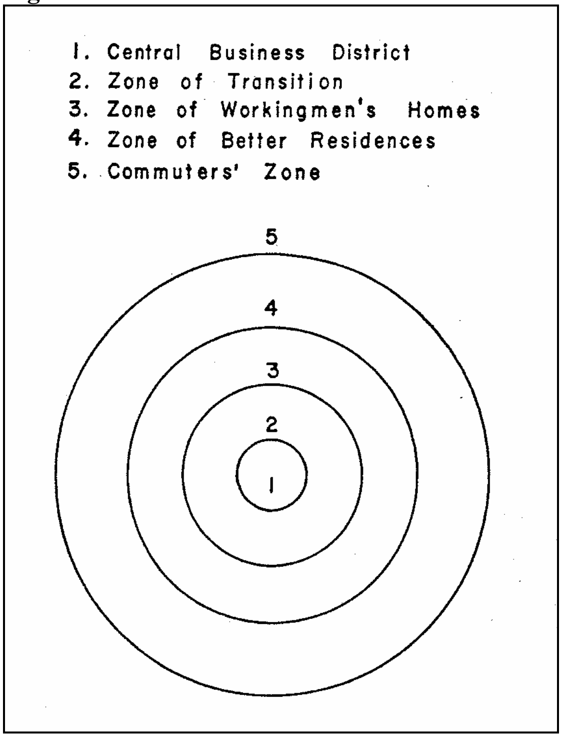
The models are often based around their author seeking to describe and explain what is and has been observable in urban development in a way that fits their views or world perspectives. For example, there are models developed that propose urban forms and their evolution in terms of economic determinants (favoured strongly by economists and market forces proponents), which interestingly were developed further according to an ecological perspective by the Chicago School of human ecology; and there are other models that are couched in terms of social determinants (favoured by sociologists and often by interventionists) (Chapin, 1957).

A key underlying difference between the explanations proposed in these two types of models is whether urban planning is desirable, useful or effective (to plan or not to plan is the key point of debate). This issue will not be explored in this project, although choosing to not plan strategically would certainly render this research project purely academic. A key related question on this difference is if strategic urban planning were not useful or desirable, would "market-forces" respond equally effectively across all objectives? Notwithstanding that debate, the following models are useful for developing an urban form classification system for the purposes of this project.

Land economists consider that as cities and towns grow and mature, they tend to show similarities as competition for land in the market place eventually averages out to produce the most efficient arrangements and distributions of land uses that are broadly similar in their relationships and layouts at the conceptual level. Within this understanding of urban development wherein economic determinants are considered the prime drivers, there were 3 early theories of urban form advanced, as outlined in Chapin (1957). These were the concentric zone theory, the sector theory and the multiple-nuclei theory, as illustrated in figures 2.3 – 2.5 (Chapin, 1957).

The concentric zone and multiple-nuclei theories describe whole urban form development, whilst the sector theory covers principally the structure of residential zone arrangements. In contrast, the concentric zone and sector theories seek to explain the development of urban forms and the multiple nuclei theory describes an urban form at a particular point in time.

Figure 2.3 Concentric Zone Urban Form Pattern



The concentric zone theory was proposed by Ernest Burgess in the early 20th century to explain the development of urban form in terms of ecological processes, but was picked up by economists to explain city development under the influence of economic forces.

Burgess depicted the city as having 5 rings or concentric zones (see Figure 2.3). At the core was the central business district or central city, with the typical range of retail, commercial, cultural, civic and tourism activities and facilities. Surrounding this is a zone of light industry, markets, wholesale businesses and lesser value commerce. Port activities, if present, would usually exist in this zone.

The next 3 zones contain largely residential activities, broadly involving in turn lower socio-economic groups, middle class households and a general commuter belt in zones 3 to 5 respectively. As growth occurs, each inner zone tends to graduate outwards, invading the next zone out, in what urban ecologists refer to as an "invasion-succession" sequence. Cutting outwards across the zones from near the edge of the central city would be rail and other major transport corridors.

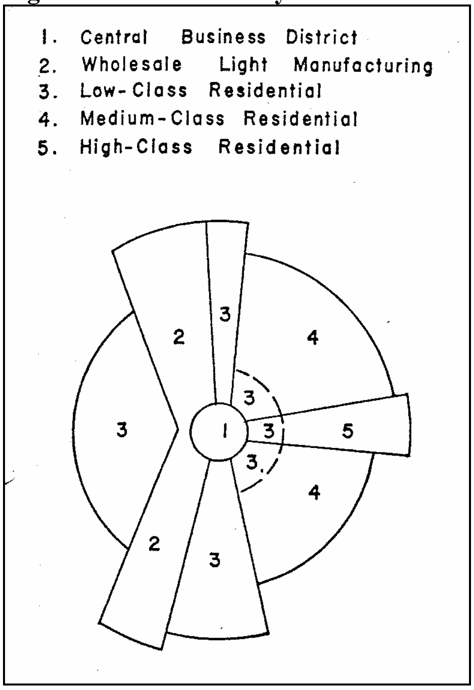
This initial theory was simple and had considerable appeal with it being a useful, visual depiction of the broad and general dynamics of an urban area at work. It was however based upon a number of key assumptions, such as competition for space exists and transport supply is equal and cheap in all directions. The model was most applicable to a major urban area undergoing significant and rapid growth. It has been noted that "*a succession of fringe belts can be identified around most towns, related to phases of active growth*." (Pacione, 2001) It should be understood in any criticisms that it was promoted as an idealisation rather than a representation of reality. "*Burgess was not unaware of the many other factors that influence city growth*." (Pacione, 2001). However, as research continued it was found in many ways to be an over-simplification (Chapin, 1957).

Following his studies of residential patterns in 1939, Homer Hoyt proposed a subsequent new theory relating to wedge shaped sectors focussed along strong radial transport corridors from the centre. This theory was labelled the sector theory, and described how different income/socio-economic groups or activity groupings in a city tended to be found in distinct districts generally based on sectors (or slices of a pie), centred on the central business district.

As illustrated in Figure 2.4, this model extends upon the concentric zone model rather than being a separate, alternative construct. A range of specific characteristics of these areas were developed, but are generally not enlightening with regard to the metropolitan level urban form, other than

> "*high-grade residential growth tends to proceed from the given point of origin, along established lines of travel or toward another existing nucleus of buildings or trading centres; and high-grade residential areas tend to develop along the fastest existing transportation lines*." (Chapin 1957)

Figure 2.4 Sector Theory of Urban Form

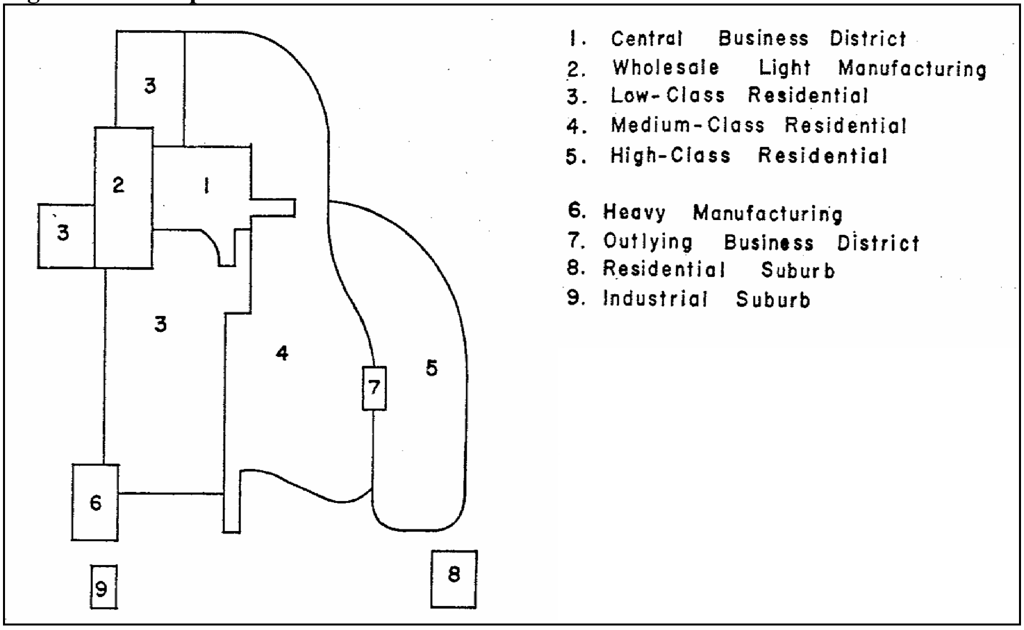


Whilst the model is weak in recognising non-residential land uses, the key benefit of Hoyt's theory was "*the profound effect the sector theory has had in stimulating awareness of the need for a theory of urban land use*" (Chapin 1957).

Later, a further theory was proposed by R.D. McKenzie which was labelled the multiple nuclei hypothesis and is illustrated in Figure 2.5. At about the same time, Harris and Ullman in 1945 observed that most large urban areas do not grow solely around a single nucleus, but often progressively subsume and integrate a number of nearby centres. (Pacione, 2001)

The McKenzie multiple-nuclei model attempted to recognise that often there can be observed a number of centres or nuclei in an urban area, rather than a single (usually central) core. It was also noted that this theory recognised the situation where through urban expansion a major urban area can subsume smaller centres initially separate to the major area, but which have retained a centre function in the enlarged urban area (as can be observed in London). The number, function and type of these additional centres vary from city to city, such as industrial centres, retailing centres, or major commercial or educational centres.

Figure 2.5 Multiple Nuclei Urban Form Pattern

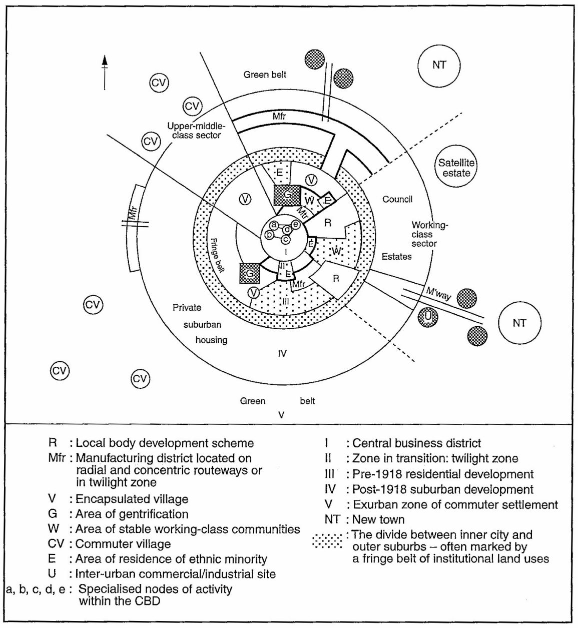


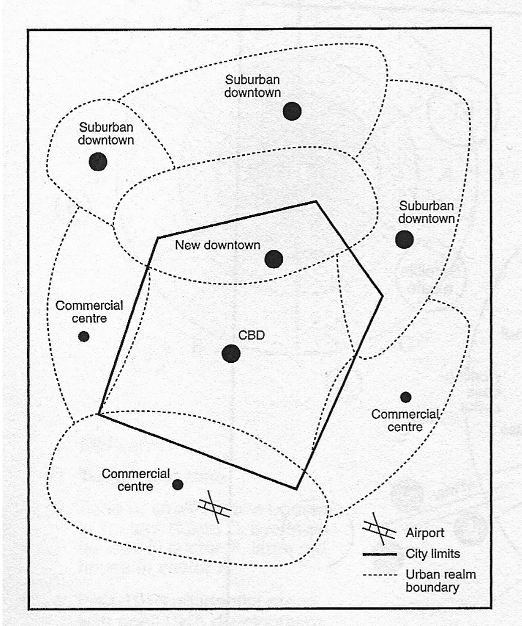
Harris and Ullman also argued that urban form and land use distribution cannot be predicted through models, as each city is unique in its responses to the differing topographies, economic/commercial drivers, cultural environment and social values of its community (Pacione, 2001).

Nevertheless, the above 3 models are considered to be the "classical" models of urban land forms (Pacione, 2001). Recent key criticisms of these models have highlighted an economic bias and lack of recognition of cultural influences (Pacione, 2001).

More recently, with the renewed interest in urban form concepts, researchers have sought to refine and improve these classical concepts. Vance (1964), Mann (1965), Kearsley (1983) and White (1987) have all proposed modifications, largely based on combinations of the concentric zones and sectors models (see Figure 2.6 for Kearsley's model), although Vance looked primarily to advance the multiple-nuclei model (see also Figure 2.6). These classical models and the more recent refinements and work provide useful insight into many western cities around the world from a simple description of what is physically observable (Pacione, 2001).

Figure 2.6 Further urban form concept developments





Kearsley's Modified Burgess Model
Source: G. Kearsley (1983) Teaching urban geography: the Burgess model *New Zealand Journal of Geography* 12, 10-13

Vance's Urban Realms Model
Source: J.Vance (1964) *Geography and Urban Evolution in the San Francisco Bay Area Berkeley*: Institute of Local Government Studies, University of California

In the later part of the twentieth century, a further urban dynamic of de-concentration caused the identification of a new urban form type, which was given a wide range of labels such as post-industrial city, edge city, mega-city, perimeter city and metroplex (Pacione, 2001). This new type demonstrated traits of declining population densities and increasing segregation of people. It was caused by a range of "push" and "pull" factors including industrial de-centralisation (post-Fordist, flexible and clustered production patterns), insecurity and negative effects of urban lifestyles, search for amenity, and improved transport and communication technologies.

The foci of these new urban forms are often located near the junctions of major transport corridors, show rapid growth, and incorporate major office space, retail space and many other key civic and community attractions (Garreau, 1991). Spatially, there is a radical restructuring, which is described as a city "*simultaneously being turned inside out and outside in*" (Pacione, 2001) and is dramatically different to earlier urban forms. It is presented as "*the urbanisation of suburbia*" (Pacione,

2001) and features a change where older central cities are reducing in population densities and becoming gentrified.

The urban form theories presented in the previous paragraphs were formulated principally by human ecologists, but have also been adopted by both land economists, (viewing the city from its economic function and development) and by sociologists looking at social structures and social class (viewing the city from its ability to satisfy human needs and interactions through organisational processes). Thus, whilst using the same conceptual basis, substantially different explanations for these urban forms are offered by land economists and sociologists despite both using urban ecology concepts.

All 3 groups of professionals have also adopted 3 key dynamics for dealing with changes in urban development and form, namely “dominance/gradient/segregation”, “centralisation/ decentralisation” and “invasion/succession”. These processes, which are explored in the following sections, relate to the adaptation of a city to the constantly changing pressures placed upon it. Economic forces are significant both in creating those pressures and in the explanation of the responses outlined in the processes.

Dominance/gradient/segregation describes how there are influences of indicators (positive or negative) which may be strong or controlling in some areas and weaker or inconsequential in others, and that there are differing gradients of change (receding dominance) from strong areas to areas of comparably weak or subservient presence of the same measure. Segregation relates to a process of clustering which tends to create and reinforce this dominance and gradient situation, rather than random or homogeneous qualities existing across the urban area. It is a selective process wherein similar “units” have a tendency to cluster, and tend to have similar characteristics such as economic strength, preferences or prejudices. It is usually not forced clustering, rather it is voluntary and occurring for many different purposes.

Centralisation/decentralisation (or concentration and dispersal) refers to the process of congregating of people or activities to a particular centre or functional area, for reasons of economic, cultural or social benefit. Decentralisation relates to the breaking down or dispersal of this aggregation, with people or activities moving away from a previous centre to peripheral areas, and sometimes leads from the single centre urban form to the multiple-nuclei form. This dynamic relates to the basic attraction or repelling processes which occur in communities for social, economic, community values, activity effects and needs, or cultural reasons. For example, location of work forces for industry, access to market places, ethnic conflict, desire for increased living space and cost of transport-needs all influence decisions of aggregation or dispersal.

Invasion/succession describes a process which usually occurs in sequence. Invasion is the entry of a new population group (social, ethnic or cultural) or economic activity to an area with pre-existing different composition. Succession occurs when the new group succeeds the previous group(s) as the dominant group in the area, and at times finally displacing it. This process is often an expression of the changing social or economic structure of a growing urban area. The process is observed to generally occur in outwardly expanding rings and to be cyclical, often starting with high status uses giving way to progressively lower status uses, until the area may experience a revitalisation or gentrification process as substantial re-investment becomes attractive again. It can lead to changes in land use regulation, and may be encouraged or obstructed by interventionist land use planning policy and regulation.

All the economic and urban ecological process explanatory concepts or influences for city development are susceptible to intervention by governmental or local community led planning, regulation and controls. Thus, given the widely diverse range of impacts, influences and histories of urban areas, the conceptual models almost are never directly applicable to a specific town or city.

2.4.3 Thomson's categories of urban form

During an interview for this research in November 2005, Ivan Thomson (Policy & Planning Team Leader, Christchurch City Council) proposed an hierarchical classification system for describing urban area structures that could be used as a basis for identifying options when developing an urban development strategy, as shown in Figure 2.7. This classification was based upon an initial assessment of an urban form as either linear, radial/concentric or dispersed. Within the first two classifications there were further sub-categories, providing a range of 7 types of urban structure, which are not necessarily mutually exclusive across larger urban areas. The following briefly outlines the categories.

Linear-continuous: An urban area which demonstrates a predominantly linear or corridor structure in a continuous, unbroken structure. It could accommodate a single strong node or central city within the linear form which is otherwise relatively homogeneous in its activity levels and land uses.

Linear-villages/nodal: An urban area which again demonstrates a predominantly linear or corridor structure but in this case has a series of nodes or "villages" or strong activity centres along the corridor.

Radial/concentric-nodal: An urban area which is essentially circular in overall shape and exhibits many of the features of the concentric zones model but with a range of nodes or "villages" or strong activity centres throughout the urban fabric (i.e. multiple-nuclei).

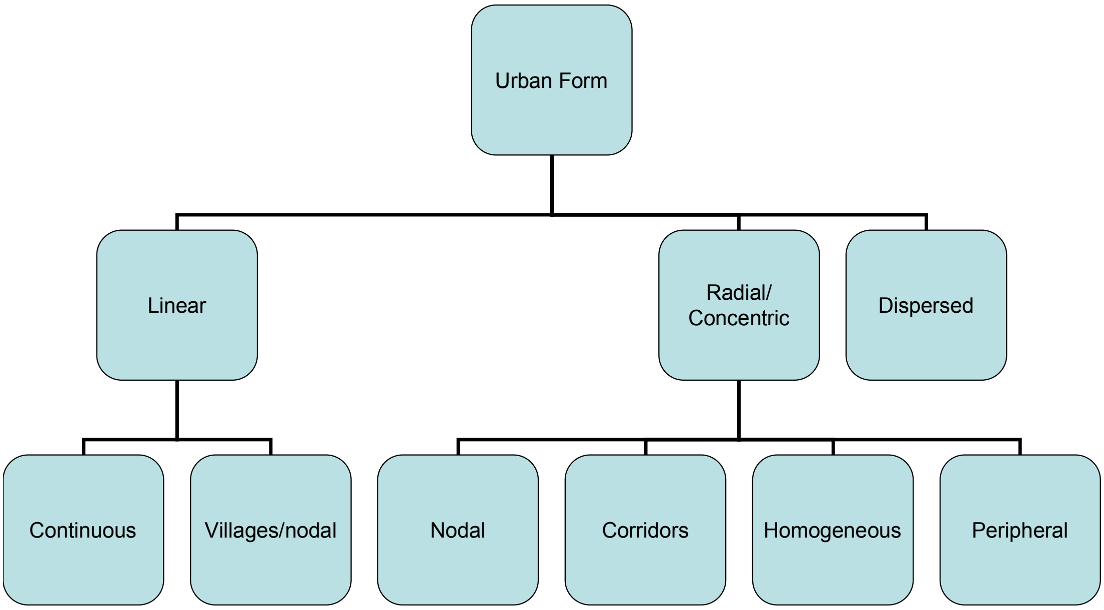
Radial/concentric-corridors: An urban area which is essentially circular in overall shape and exhibits many of the features of the concentric zones model including a range of strong (usually radial) transport corridors through the urban area, normally connecting key activity areas to each other and to the urban area's gateways.

Radial/concentric-homogenous: An urban area which is essentially circular in overall shape and exhibits many of the features of the concentric zones model including the very dominant central business district with no major additional centres or other strong nodes. (i.e. mono-centric)

Radial/concentric-peripheral: An urban area which is essentially circular in overall shape and exhibits many of the features of the concentric zones model. However in addition to a central city node (which may be relatively weak), strong activity and attractions exist at the periphery of the urban area, creating something of a "wheel and hub" or annulus arrangement of the urban form.

Dispersed: An urban area which is homogeneous throughout and lacks any defined core, corridors or nodes of higher activity or groupings of land uses.

Figure 2.7 Urban Form Classification System proposed by Thomson



2.5 Urban Development Strategies in New Zealand

In this section, Urban Development Strategies (UDS's) are described and New Zealand's UDS's are identified and presented in terms of their aims and objectives, linkages to other documents and key issues.

2.5.1 Introduction

Urban development strategies (UDS, which may be called any of a range of other titles, such as regional growth strategy, Smart Growth Strategy, or urban form plans) have been or are being developed in a range of New Zealand centres, such as Auckland, Bay of Plenty, Wellington and Christchurch. They are collaborative agreements between a range of agencies involved in responding to or influencing the issues raised by the area's growth (essentially land-use regulatory and road controlling authorities). Transit New Zealand, the state highway agency, is involved as an active partner in the development of some, but not all (such as the Western Bay of Plenty Smart Growth Strategy, produced only by the Regional, City and District Councils in the area).

UDS's seek to provide strategic direction for managing the (largely physical) development of an urban area. The development of such strategies reflects the desire of communities and their local government to work in cooperation to address and resolve urban growth issues, which would otherwise create significant negative effects on their community. This is often driven by issues and concerns about improving outcomes related to housing, urban design and accessibility (in contrast to a laissez-faire approach) from projected sustained and/or rapid growth (usually in population numbers, but potentially major economic development). Other drivers can include potential impacts on sense of identity and the natural environment, and confidence and certainty of the most efficient use of public resources.

The current development of these strategies is occurring in the context of perceived poor recent outcomes of growth occurring in an environment of "*lack of leadership and coordinated arrangements to manage that growth.*" (Joint Western Bay of Plenty Councils, 2004)

In relation to these drivers, the Wellington Regional Strategy development indicates that its "*aim is to build an internationally competitive region while at the same time, enhancing our quality of life*." (WRSF, 2005) Similarly, the Auckland Regional Growth Strategy notes that its purpose is "*to ensure growth is accommodated in a way that meets the best interests of the inhabitants of the Auckland Region*" and is constructed in such a way as to provide a "snapshot" of how Auckland could look in 2050 if the strategy is achieved. (ARGF, 1999)

In its background, the Western Bay of Plenty SmartGrowth Strategy noted explicitly what other urban development strategies in New Zealand tend to infer, related to the situation that if "*local government does not show leadership, the development community will determine priorities and shape the future of the sub-region*".

Supporting this, it also noted that the Resource Management Act (RMA), with its narrow "effects" (and sustainable management, rather than sustainable development) focus "*fails to provide a platform for development of a broad community vision of the future addressing environmental, social, cultural, and economic issues in an integrated manner*." This clearly indicates the desire to not allow "market forces" to be the means of response to growth, because if left to its own, the market will not deliver sustainable outcomes. The preferred response is intervention that allows communities to determine collaboratively, through active and intentional planning, how the growth should be accommodated and optimised for their benefit.

2.5.2 Aims and Outcomes

UDS's seek to set out a Vision for the future and provide better certainty as the region grows and develops. All New Zealand strategies reviewed are based on the decision that a "business as usual" future is not wanted, and the Vision (or related sections) is meant to articulate what the communities desires are for the future, in the context of the projected growth.

The Greater Christchurch Urban Development Strategy (GCUDS) consultation summary report (GCUDSF 2006-1) states in its conclusions that "*this represents a major shift from the 'business as usual' approach to one of a more strategic planning approach with a greater focus on protecting environmental and community character values.*" This is the same desired outcome as the Christchurch City District Plan (an RMA-based document), which has failed to deliver it. The success of GCUDS will be assessed against whether it delivers its outcomes through its implementation. Overall, UDS's assist "*key stakeholders in understanding the likely scale and form of future growth and the consequent infrastructure priorities*." (Auckland Regional Growth Forum, 1999)

The Visions tend to be very similar between urban areas, as basic human desires for their surroundings (when in an urban area, rather than living in more rural or undeveloped areas) do not vary substantially. Key themes of the Visions relate to ensuring an area (continues to) be an attractive place to work, invest live and play, to improve certainty for business development and growth, improve accessibility and ease of movement and protect the natural environment from adverse effects of growth. The themes revolve strongly around the overarching concept of quality of life for the inhabitants and businesses in the urban area (the stated "strategic aim" of the Greater Christchurch Urban Development Strategy in its charter (GCUDSF, 2006-2)).

The Western Bay of Plenty SmartGrowth Strategy (2002) provides a useful insight into the concept of "live, work and play" by describing it as

> "*a concept that emphasises the need for balance within the management of growth ... it includes the provision of land and services for housing, business, rural production, community activities and recreation. It emphasises the inter-relationships of these activities to provide for accessibility, minimised energy use, and reduced vehicle emissions.*"

Supporting the Vision in these strategies is an array of strategic directions, outcomes, objectives, principles and policies, and sometimes these are taken through to action plans. The Western Bay of Plenty SmartGrowth Strategy outlines an extensive range of implementation methods which constitute over 60% of the total document. In contrast to this, the Auckland Regional Growth Strategy, whilst intending to set initial priorities for significant infrastructure, does not go to detailed planning, stating "other sector and local growth plans and strategies will be developed to give effect to this strategy at a more detailed level."

Urban Development Strategies cover a wide range of desired Outcomes, urban interactions and systems, such as the location and distribution of housing and commercial activities, provision and operation of open space, management and development of the transport system, protection and management of natural resources of an urban area (such as quantity and quality of its water supply), maintaining its sense of place and character, and promotion of special purpose areas (e.g. Central City).

The Outcomes used are derived either from separately conducted consultation for the purposes of the strategy development (e.g. Christchurch) or are drawn directly from the Community Outcomes expressed in the contributing Council's Long Term Council Community Plans (e.g. Wellington).

The Auckland and Wellington strategies also present "Principles" which appear to be interpretive statements and descriptions to assist in understanding how to translate the high level Outcomes when assessing implementation alternative measures and actions. Wellington's documentation describes them as "*the qualities of urban development, economic development and transport that will deliver the outcomes. All proposed actions arising from the Regional Strategy will be 'tested' against the principles, to ensure sound decision making.*" (Wellington Regional Strategy, 2005)

2.5.3 Linkages between Urban Development Strategies and other documents

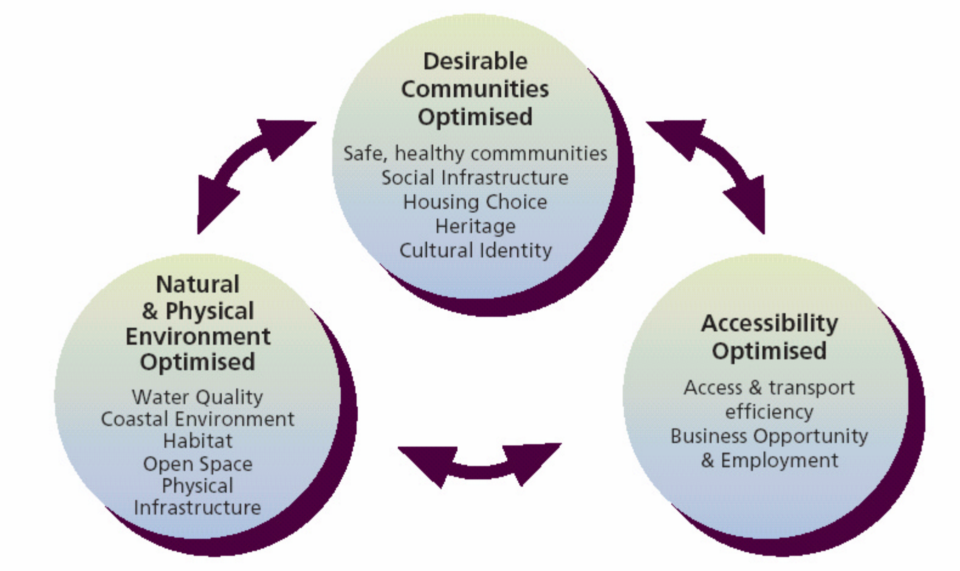
The linkages and interactions between these various elements are recognised in the strategies. The Greater Christchurch Urban Development Strategy Community Charter (GCUDSF, 2006-2) is typical in stating that

> "*the strategy must consider the complexity and inter-relationships of issues around integrating land use and infrastructure (especially transport, water and energy) whilst giving effect to the social, cultural, economic and environmental values and aspirations of the Greater Christchurch communities.*"

The Auckland Strategy notes that recognising and addressing the linkages between the elements is critical to the successful outcome of the strategy This has been expressed in various ways, such as shown in Figure 2.8, Figure 2.9 and Figure 2.10 below taken from the Auckland Regional Growth Strategy, the Wellington Regional Strategy and the Greater Christchurch Urban Development Strategy work.

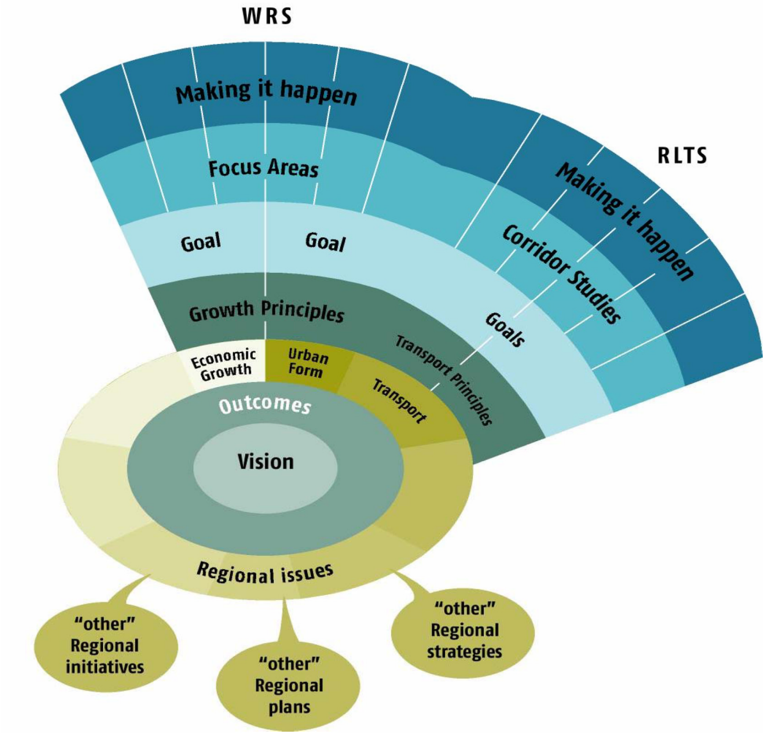
Figure 2.10 below, drawn from the Greater Christchurch Urban Development Strategy work, shows the wide range of interactions and linkages involved with an urban development strategy. Within the GCUDS itself, there are the urban interactions and systems, such as the chapters (or sub-strategies) dealing with housing and commercial activities, open space, the transport system, natural resources (such as quantity and quality of its water supply), maintaining its sense of place and character, and special purpose areas (e.g. Central City).

Figure 2.8 Inter-relationships between key themes from Auckland Growth Strategy



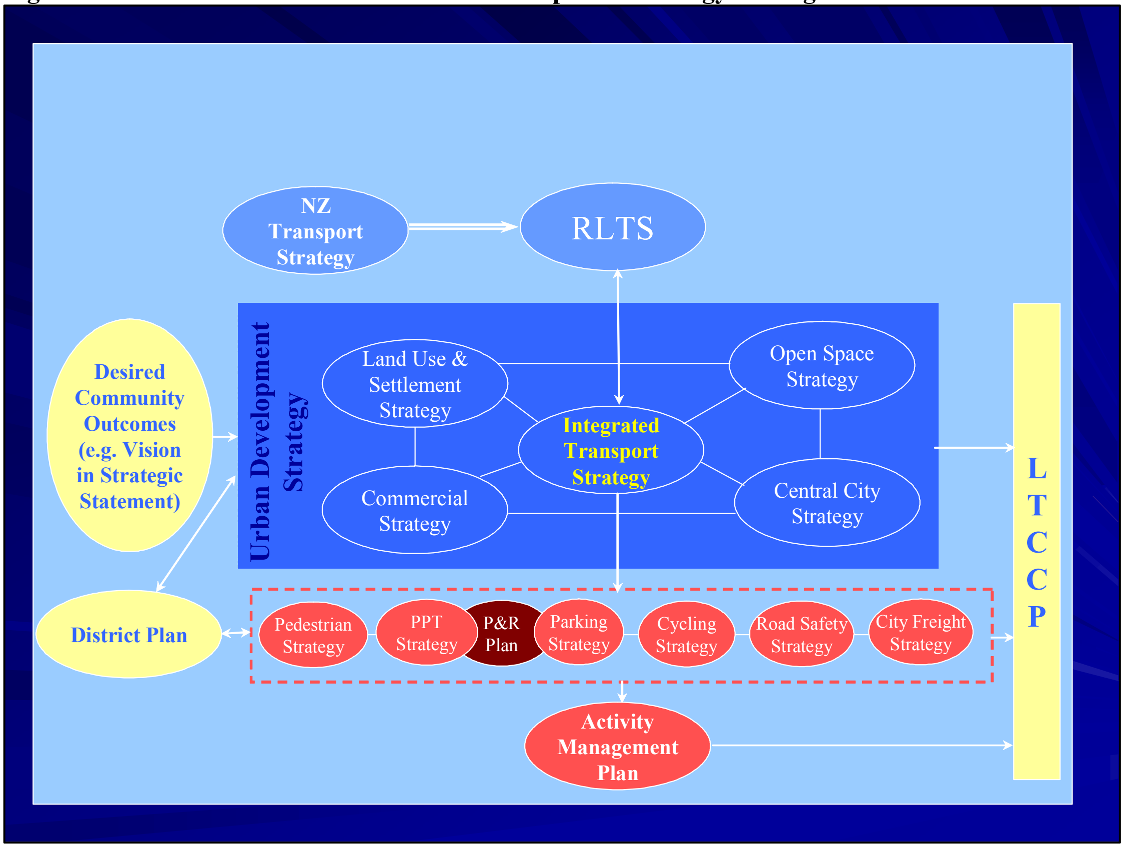
Source: Auckland Regional Growth Strategy: 2050, Auckland Regional Council (1999)

Figure 2.9: Relationships of elements of the Wellington Regional Strategy



Source: Wellington Regional Strategy: Proposed Regional Outcomes, Greater Wellington (2005)

Figure 2.10 Greater Christchurch Urban Development Strategy Linkages



The Integrated Transport Strategy, in the Christchurch context, is seen as an umbrella document, co-ordinating cross organisational and boundary issues and setting governing policy direction for the transport system development for each of the partner organisations. Linked (directly or indirectly) to the GCUDS Integrated Transport Strategy are component strategies (of the partners) in some form or other. In the case of Christchurch many of these are in place and there is also a temporary Metropolitan Transport Statement in place (until GCUDS is completed).

Any park and ride strategy or plan for an urban area would exist at that lower level. It is shown here as a separate strategy, but linked to the Parking and Public Transport Strategies. Different organisations and cities treat Park and Ride in various ways from a policy perspective. Some have implemented it without any guiding policy or strategy context, some have subsumed it in one or other larger strategy, some have it covered by policy statement in the integrated strategy (then having an independent implementation plan) and others employ an entirely separate component strategy.

Figure 2.10 also indicates the linkages to other documents and statements, such as regional and national transport policy, Long Term Council Community Plans (LTCCP's), District Plans and Activity Management Plans. The connections to wider transport strategies, particularly the Regional Land Transport Strategy (RLTS) and the non-statutory New Zealand Transport Strategy, indicate that an urban area's transport system is not developed in isolation from wider regional and national transport policy and directions. In the case of the Western Bay of Plenty SmartGrowth Strategy, it is intended that the strategy's transport aspects will be "*a significant sub-regional component of the RLTS*." There are also a range of other higher level transport documents to be considered, such as the National Energy Efficiency and Conservation Strategy and the Vehicle Fleet Emissions Control Strategy.

The "Desired Community Outcomes" are what the community wants for its city/town/area, and New Zealand local authorities are required by the Local Government Act 2002 to establish or review these every 6 years or less. They are sometimes captured by a Vision statement and/or are supported by a range of strategic objectives to develop the detail. They can relate to physical matters (as well as social services and welfare, economic development and civic and governance processes), hence there may be links to an urban development strategy (as noted above, some UDS's have simply drawn directly on these as a basis for strategy development).

A Long Term Council Community Plan (LTCCP) is like a Council's contract with its community. It develops the identified "desired community outcomes" and outlines how the Council will undertake or achieve them, including partnerships, key projects or initiatives (such as Park and Ride introduction), financial plans and budgets. These documents should include the detail and commitment of a Council in meeting its responsibilities to an urban development strategy.

District Plans are required under the Resource Management Act. They are the legal planning document which a local authority uses in seeking to sustainably manage the physical and natural resources of a district for its current and future community. They deal with land use activity and cover a wide range of planning detail, from general issues identification for a district, through the vision, objectives, and policies, down to specific rules. As they are constrained both in their focus and the possible mechanisms to achieve a community's strategic development desires, they are increasingly being seen as a tool to execute aspects of policy, such as urban development strategies or transport strategies, rather than being the driver.

Activity Management Plans are expanded asset management plans, now including (sustainable) planning of non-asset related activities and setting Service Levels for all activities. Through the Service Levels, Activity Management Plans form a key input to the LTCCP budget production (and therefore are an important link in delivering the outcomes of an urban development strategy or Park and Ride system).

2.5.4 Issues for Urban Development Strategies

There is a potential for conflict between different identified desired Outcomes of Urban Development Strategies. For example, the Auckland Regional Growth Strategy notes that "*in many situations they* (the desired Outcomes) *may be in conflict or not support each other. Resolving these conflicts involves prioritising outcomes*". It prioritised its outcomes by allocating each outcome to one of three priority levels: critical, very important and important, but recognised that the priority assigned to an outcome could vary across the region geographically and also through time.

It is vital that the internal chapters of an Urban Development Strategy are integrated and as internally consistent as possible, as well as being well co-ordinated with impacting external policies, requirements and influences. A regular criticism of strategic plans for urban areas is the lack of integration between land use and transport strategies. To overcome this issue, the UDS's need to provide a framework for integrated decision-making and conflict resolution.

This internal integration is required not only at the strategic policy level, ensuring that the high level strategies are integrated, but also it is required **within** all the component parts that may form, contribute to or sit under each of the high level strategies. For example, transport projects and operations **should** all be consistent with and contribute to the Integrated Transport Strategy and therefore contribute to the wider urban growth strategy. Without this care, it can be seen that individual measures (such as Park and Ride system implementation) may contribute to or obstruct the optimal achievement of the objectives or desired outcomes of an urban development strategy.

It is apparent there are many possible relationships and many opportunities where measures can assist or hinder the community achieving its desired outcomes, and sometimes the connection or relationship may not be obvious.

2.6 Urban Form Objectives

Historically urban form analysts and researchers have looked at how urban forms have developed and sought to identify the driving forces that created the urban forms. The analysis did not generally recognise any specific objective setting at a metropolitan level, rather the collective impact of a range of underlying drivers. These underlying drivers tended to depend on the background disposition of the researcher, such as the land economists or sociologists, as noted above. Thus the inferred urban form objectives were either related to market forces and economic efficiency requirements, or to social needs and interactions of the community. Few recognised issues related directly to transport (some were indirect, such as accessibility which affects the economics and desirability of certain areas or zones), and neither were the analyses accepting of a range of objectives or drivers from across the breadth of urban planning, let alone considering their interaction.

As noted in the previous section of Urban Development Strategies, urban form planning processes usually involve the establishment of a Vision for the future, and a range of associated objectives. These objectives relate to a range of the issues which may collectively provide an indication of whether the Vision has been achieved, or at least whether progress is being made towards it.

The objectives may be quite explicit as occurs with the Auckland Regional Growth Strategy, or not be identified specifically whilst still being present, such as occurs in the Vision statement of the Western Bay of Plenty Smart Growth Strategy.

In reviewing strategic planning documents, both statutory (such as Regional Policy Statements) and non-statutory (such as the urban growth strategies), it is clear that there can be established several levels within an hierarchy of objective-type statements. Different agencies and processes label these variously outcomes, objectives, policies, goals, etc.

There appear to be very common themes and directions in the Vision statements for urban form planning, and consequently a strong degree of consistency may be seen between the objectives derived from these Visions. The main differences between the desired futures for various urban areas seem to lie principally in the weightings being placed throughout the objective set.

The objectives identified in this literature review appear to be created at a number of differing levels of strategic consideration, from high level, general objectives, down to quite specific objectives related to a particular issue or impact. These objectives at whatever level can relate to a very wide range of matters related to a community's desires for its future urban form. Some may relate to transport matters, indirectly or directly. Other objectives may relate to matters such as privacy, warm housing, regional open space provision, provision of community facilities and water supply.

This literature review has identified a range of objectives affected by or which affect transport and has grouped them in three levels of objectives as indicated in Figure 2.11 Urban Form Objectives, grouped by level. These are derived principally from the urban form planning work related to the Auckland Regional Growth Strategy, the Western Bay of Plenty Smart Growth Strategy, the Wellington Regional Strategy and the Greater Christchurch Urban Development Strategy. The levels used are:

- Level One Objectives (Outcomes) tend to be quite generic and common across urban areas, and can link to a wide range of other issues not directly related to transport, such as amenity, urban design, community interaction or access to open space.

- Level Two Objectives are more detailed than the Level One Objectives, and can be seen to be more specific to transport outcomes.
- Level Three Objectives are more detailed again, and it is easier to see the specific measures from which they may be assessed.

Figure 2.11 Urban Form Objectives, grouped by level

1st Level Objectives - Outcomes

- Economic development
- Environmental sustainability
- Safety
- Public health & security
- Accessibility
- Energy efficiency
- Social equity

2nd Level Objectives – General Objectives

- Nodal urban form
- Reduce need for car use
- Connections, linkages & corridors
- Manage congestion
- Walkability
- Use of environmentally friendly modes
- Minimise operating costs
- Improve air quality
- Minimise noise
- Adequate provision and efficient use of land
- Community interaction opportunities
- Adjust to aging population

3rd Level Objectives – Specific Objectives

- Supports central city
- Supports suburban nodes
- Local air quality – centrally
- Local air quality – suburban areas
- Global air quality
- Local noise - centrally
- Promote and improve walking centrally
- Promote and improve walking suburban areas
- Promote and improve cycling and public transport
- Minimise vehicle kilometres travelled
- Increase net regional product
- Minimise social cost of crashes
- Minimise fuel and energy use
- Effective and efficient infrastructure use

There are "many-to-many" relationships between the objectives at different levels. That is, each objective generally impacts on and is impacted on by many other objectives and as such they tend to all be indirectly related (see Figure 2.12 and Figure 2.13).

Whilst the relationship diagram in Figure 2.13 for the level 2 and 3 objectives looks very dense in the number of relationships identified, there are clearly some much stronger relationships than others. For example, an objective to improve air quality has a much stronger relationship to improving global air quality than an objective to manage congestion has to promoting and improving walking centrally.

Figure 2.12 Urban Form Level One & Two Objectives Relationships

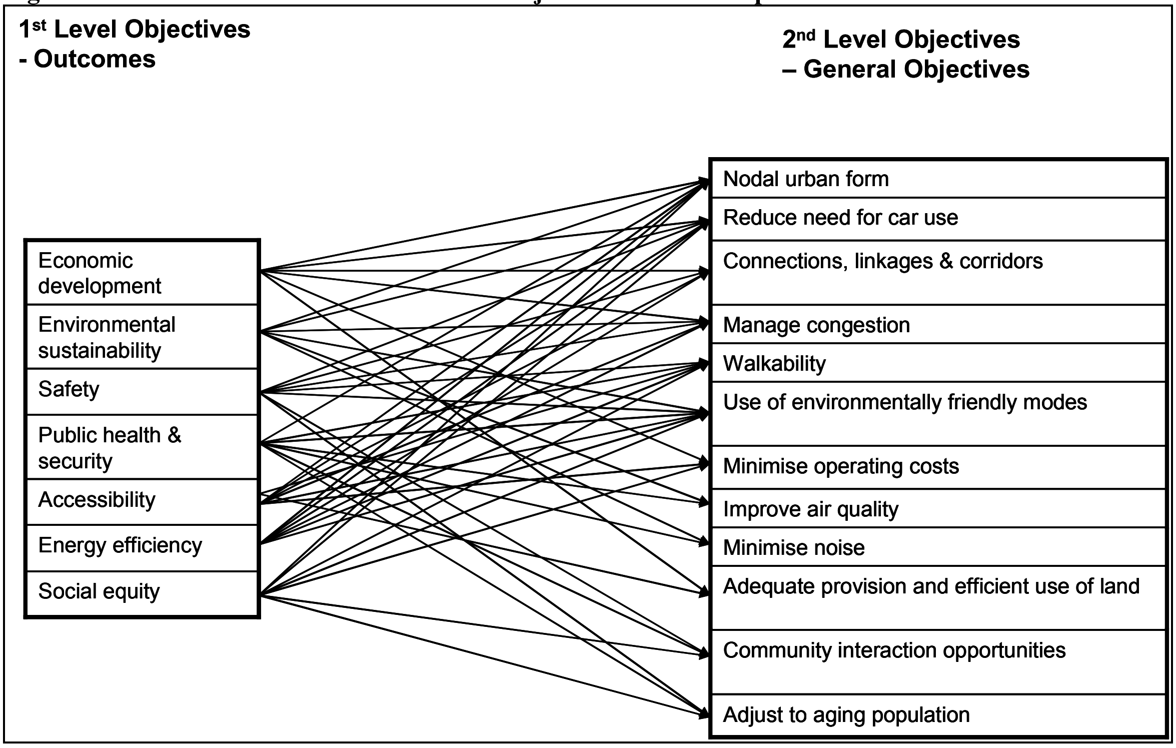
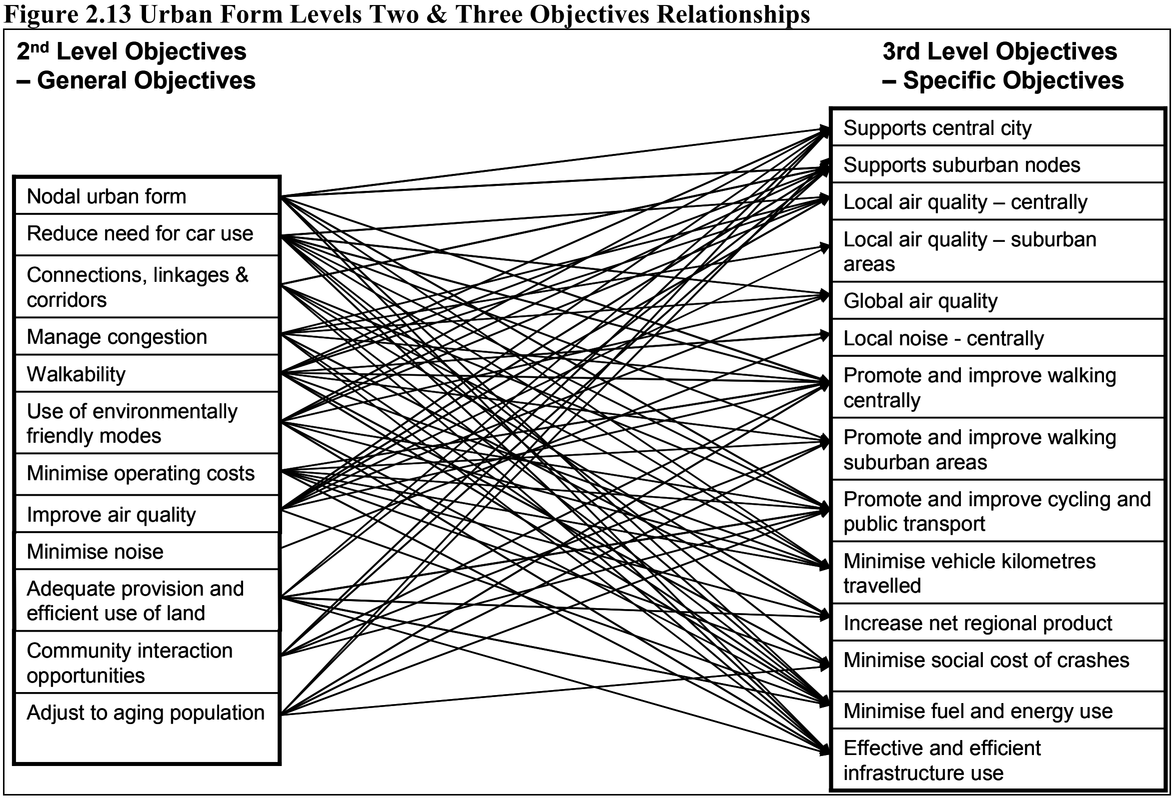


Figure 2.13 Urban Form Levels Two & Three Objectives Relationships



2.7 Decision-making and Assessment Techniques

This section reviews analytical techniques which may be used to assist decision-making. It covers a brief overview of the decision-making process and presents information on single and multi-criteria analysis methods. Material is also included on weighting processes used in multi-criteria analysis with a focus on the Analytical Hierarchy Process.

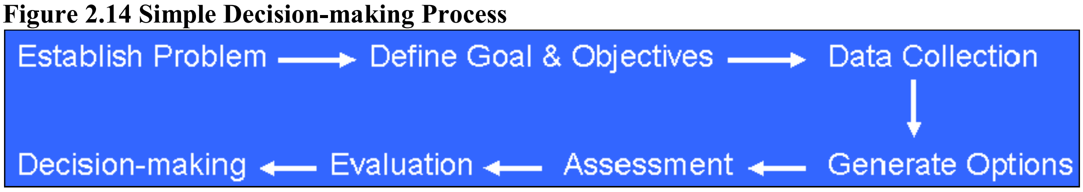
2.7.1 Introduction

Decisions can range from very simple where only a single person is considering one variable against a single criterion with low consequences involved, through to highly complex with many variables that are measured by different metrics or methods and a diverse decision-making group with divergent objectives, understanding and stakes.

Decision making may be made via rational process (as discussed below) or by less explicit processes, such as the implicit or even intuitive decision-making processes by markets usually informed by some level of economic information.

The likelihood of a good decision is increased significantly by the use of a robust decision-making process. A key ingredient in that process is the strategy of breaking the decision problem into small component elements, analysing each and then appropriately aggregating the parts to provide information to make the decision. Figure 2.14 below outlines the basic decision-making process in a simple 7 stage form (derived from Meyer and Miller, 1984). This project report deals with stages 2-5 predominantly.

Figure 2.14 Simple Decision-making Process



The third stage of data collection is the straight-forward process of collecting relevant information required or desired to be included in the decision-making process. This can involve base data collection through experimentation and/or observation, research and collection of existing data or information, or collection of people's views and knowledge. This is the raw data and input to the process.

Assessment methods or techniques take the raw data and analyse, reduce, arrange, combine or manipulate it to allow rating, patterns, trends or outputs to be identified. Essentially they take raw data and seek to place order and sense on it. They could be seen as taking the raw data and manipulating it so that it becomes information.

The outputs of these assessment methods or techniques assist decision-makers to make their decisions. Ideally they also allow more transparency and objectivity to be observed in that decision-making by the affected parties or key stakeholders interested in the decision. The assessment technique is not the decision maker itself, but contributes to the evaluation or decision-making process in which other influences and processes can contribute to the final decision of the delegated decision-maker.

Assessment techniques are a key part of an evaluation process. Evaluation has been defined as "*an assessment of the value of an activity as measured by its success or failure in achieving a predetermined set of goals or objectives*." (FHWA, 1981). They become more significant as evaluations or a decision become more complex or important. In the evaluation of complex and/or important situations, assessment techniques allow a transparent, considered and rational process to occur, ideally capturing explicitly all matters identified as contributory or influential.

Thus as a stage in decision-making, Meyer & Miller (1984) state that evaluation is "*the process of assessing the advantages and disadvantages of different courses of action and presenting this information to decision-makers in a comprehensive and useful form*." They go on to say that "*evaluation is the process of determining the value of individual alternatives and the desirability of one alternative over another*." This process interprets the information from the assessment stage, preferably using a robust and transparent framework involving the key targets or objectives. This stage is where various alternatives and options are compared against one another (using the evaluation framework) and some technical or process-based judgements (which may incorporate “lay” or non-technical opinions) are made from the results, which do not occur in earlier stages. The outcomes of the evaluation process are then compiled and prepared (as reports or presentations) and provided to decision-makers to deliberate. As Feldt (1988) notes “*Urban planners themselves seldom make decisions, rather, they lay out major alternatives and recommendations for those elected or appointed to make such decisions*.”

The final stage is that decision-makers deliberate on all the information, influences and environments which are known to them and impact on the decision. At this stage, the decision-makers also need to grapple with any identified matters not dealt with through the earlier stages, which may be gathered under groupings such as unknowns, intangibles and externalities. The process may take many forms, and may not appear to be particularly rational in its final outcomes as the decision-makers consider all matters.

There is an increasing range of types of assessment techniques that may be used in decision-making processes. It is a very rare decision-making process wherein all the factors involved exist in their base form in the same measure, such as monetary or deaths. Therefore the types of assessment method can be grouped into two types, either seeking to convert the factors into a common measure (such as money) or to construct a framework where differing factors can be compiled into a profile for each option to be compared.

Most methods related to the first alternative of conversion of factors to a common base seek to use a financial base or some form of economic analysis. The second alternative tends to have methods based in some form around multi-criteria analysis (MCA). Also called scoring techniques, they include methods such as standard MCA, sustainability assessment model (Landcare, 2004) and quadruple bottom line assessments. To a degree most political decision making, and many final stage decision-making processes use some form of multi-criteria assessment or trade-off between factors and influences, either explicitly or implicitly.

A potential pitfall for the decision-making process is to rely upon a single analytical approach as the sole means of determining a best option through the assessment and informing of the decision-making process, rather than seeking to provide comparative information and increasing a decision-makers understanding of the options.

2.7.2 Single Criterion Analysis: Economic Analyses

The simplest and a very common form of comparative assessment is that using a single factor method, and most often this involves reducing benefits and costs to monetary terms to perform some sort of economic analysis and comparison. Some even consider that there is no decision-making involved when employing a single criterion process (using a single attribute, an objective function or single aggregate measure like costs), as the decision is made implicitly in the calculation (Schreck, 2002).

Economic analyses are a group of single factor type assessment methods, where the various data assessed are all converted to a monetary basis. The methods include benefit-cost analysis (covering benefit-cost ratios (BCR) and incremental benefit-cost ratios (IBC)), net present value (NPV), annual cost method (ACM), and return on investment (ROI). These key types of single criterion analysis are outlined below, briefly describing the calculation and presenting the key equations.

Benefit cost analysis assesses the ratio of costs to benefits and risks of options or different projects to allow comparison between them. The basis of the Benefit-Cost Ratio analysis is to derive present day values for the assessed benefits and costs, and calculate their ratio (Equation 2.1).

$$BCR = B / C \qquad \textit{Equation. 2.1}$$

Where:

BCR = Benefit Cost Ratio

B = summed discounted present value of all the assessed benefits

C = summed discounted present value of all the assessed costs

Some analysts prefer to calculate the benefit cost ratio by using a net benefit for the numerator as indicated in Equation 2.2. This is the procedure adopted by Land Transport New Zealand in their Project Evaluation Manual for risk analysis. Whilst this equation provides a better direct value of the benefit derived for every dollar spent, the only difference in result is a reduction in the BCR of 1.0.

$$NBCR = (B - C)/ C \qquad \textit{Equation. 2.2}$$

Where:

$NBCR$ = Net Benefit Cost Ratio

Incremental Benefit-Cost Ratios (IBC) are calculated through an iterative process. The alternative projects are listed in order of cost from cheapest to most expensive. The difference between the costs and benefits of the cheapest (base) and next cheapest options are calculated and calculated as a benefit/cost ratio. If this ratio is over a certain cut-off value, then the higher value project option becomes the new base project. If the ratio is below the cut-off threshold, then the higher cost option is ignored, the base project remains as the lower cost option, and the next most expensive option is assessed against the base option. This process is repeated until all more costly projects are compared against the base project. In effect the calculation could be expressed as:

$$IBC = (B_h - B_l) / (C_h - C_l) \qquad \textit{Equation. 2.3}$$

Where:

B_h = Summed present value of all benefits of the higher cost project h

B_l = Summed present value of all benefits of the lower cost project l

C_h = Summed present value of all costs of the higher cost project h

C_l = Summed present value of all costs of the lower cost project l

The Net Present Value (NPV) method simply calculates the present value of the various benefits and costs, and sums these present values (as indicated in Equation. 2.4). This provides a single figure indicating the sum increase or decrease of costs to the system as a result of the project or alternative. A recommended option would be that with the greatest positive NPV.

$$NPV = \Sigma(PVB_i) - \Sigma(PVC_j) \qquad \textit{Equation 2.4}$$

Where:

NPV = Net Present Value

PVB_i = discounted present value of each benefit i of the alternative through time.

PVC_j = discounted present value of each cost j of the alternative through time.

The Annual Cost Method (ACM) is based on calculating the average annual cost from the creation, maintenance and operation of each alternative over the assessment period using discount rates, and then comparing the alternative annual costs (as noted in Equation 2.5). The recommended option from this analysis would be the option with the lowest annual average cost. This could assist with cost-effectiveness assessment discussed in the next section.

$$ACM = \left(\sum_i \sum_j c_{j,i} / (1+r)^i \right) / n \qquad \textit{Equation 2.5}$$

Where:

ACM = Average annual cost

PVC_j = discounted present value of each cost j of the alternative through time.

r = discount rate

i = year number, e.g. 1, 2, 3, up to n years

n = number of years costs are averaged over (often 20 years)

The Return On Investment (ROI) method seeks to find the interest rate that would equate the present value of the benefits and costs of an alternative. A high interest rate would indicate good benefits (net of costs) in early years, or that the initial costs would be recovered by revenue (benefits) streams quickly. Lower interest rates would indicate a longer return period (either through lower revenue streams early on, or later cost streams). It requires an iterative process seeking to solve Equation 2.6 below:

$$\Sigma(PVB_{i,r}) = \Sigma(PVC_{j,r}) \qquad \textit{Equation 2.6}$$

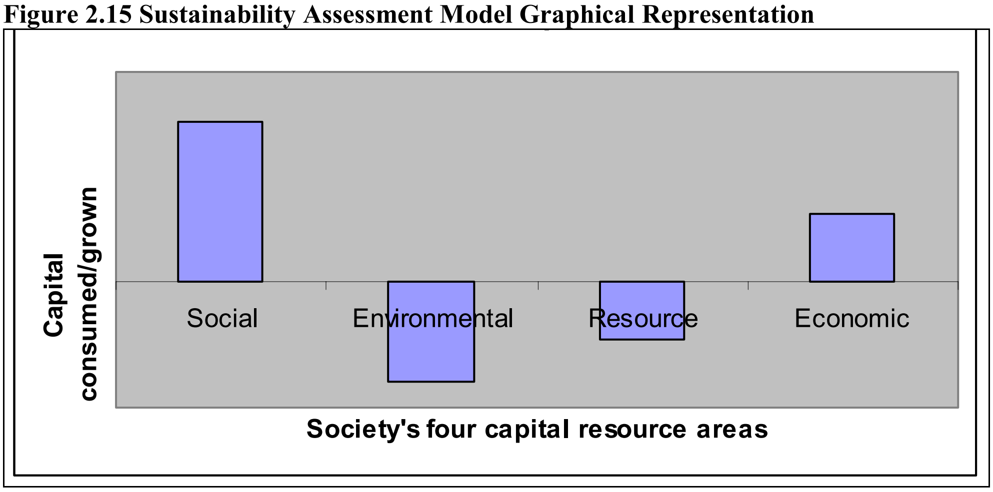
Where:

$PVB_{i,r}$ = discounted present value of each benefit i of the alternative through time under discount interest r.

$PVC_{j,r}$ = discounted present value of each cost j of the alternative through time under discount interest r.

There are a range of applications of the methods for single criterion assessment described above in regular use, including in New Zealand. For example, a recently developed application or variation of the above single-criterion assessment developed in New Zealand has an initial appearance of multi-criteria analysis, but is in fact still a single-criterion assessment method. It is labelled the "Sustainability Assessment Model" (SAM) (Frame, 2004). The purpose of SAM is a tool for modelling and evaluating sustainable development profiles of projects, project ranking and to promote and enable sustainable development thinking in organisations.

Figure 2.15 Sustainability Assessment Model Graphical Representation



It assesses the amount of "capital resources" a project consumes or creates, grouped under four headings (see Figure 2.15). Monetary units are used for all categories for the assessments. The four groupings are:

- Social : Jobs, taxation, product/service, reduced crime and fear of crime, impacts on other users of the space, equipping/up-skilling community, health and safety improvements;
- Environmental : Energy used, water used, waste created, land footprint, noise/visual/odour nuisance;
- Resource : Physical infrastructure costs, raw materials, intellectual capital; and
- Economic : Payments to contractors, reinvestment, dividends, taxes.

The SAM index is then calculated by assessing the proportion of created resource compared to all the capital resources associated with the project (see Equation. 2.7).

$$SAM_i = GCR / (GCR + CCR) \qquad \textit{Equation 2.7}$$

Where:

SAM_i = SAM index

GCR = Growth or created capital resource

CCR = Consumed capital resource

Note – both GCR and CCR are measured as positive values

These assessments have been trialled on Christchurch City Council's South Christchurch Library and a comparison of the Strickland Street Community Garden against the current Christchurch land fill for disposal of organic waste.

A significant benefit of the economic analysis methods is that it is not necessary to derive weights for the various benefits or costs variables, as they are expressed in a common (monetary) measure.

The key disadvantage of economic analyses is the reduction of all variables to a single factor or single scalar dimension (in this case money), as there are often variables or issues for which it is not easy to obtain a monetary value. Some areas for which variables or issues are not easily measured in monetary terms are compliance with laws and regulations, impact on air quality, community cohesion, energy consumption, and equitable distribution of resources (Meyer and Miller, 1984). The consequences of this are that, for example, the uncertainty and variability of the valuations are usually not recognised (Womer *et al*, 1996), and the factors for which a monetary value cannot be assigned might be set aside in both the assessment and the following decision-making.

The factors which are not valued in the economic assessment of a project fall into one of three categories: intangibles, externalities and unknowns. Intangible variables (costs or benefits) are those which are not able to be expressed (readily) in monetary terms. Externalities are those variables (costs or benefits) which are not borne directly by the users or stakeholders of a project, such as public health costs of adjoining property owners caused by traffic emissions from an adjoining road. Unknowns are exactly what their name is, and can only be conceptually recognised in their absence.

These categories of variables should not be ignored or neglected (noting that unknowns are indeed unknown!). Externalities should be "internalised" into the project assessment where possible. In all three cases, the variables should be identified and fully described (type, duration, level of effect and change from status quo, etc.) in the project assessment documentation.

Another disadvantage is that these economic analyses do not recognise distributional effects and therefore do not inform about the level of effects on differing affected parties or issues, or when they occur.

These economic analysis methods (e.g. benefit-cost assessments) have also been criticised due to their potential ambiguity of results and the variations that can occur due to the (arbitrary) definition of costs and benefits in the analysis (Meyer and Miller, 1984). The results are also very susceptible to discount rates (affecting the impact of the distribution of costs and benefits over time). This is a key debate regarding sustainability and environmental economics, as only (very) low discount rates truly recognise the values and benefits still occurring long into the future.

These traditional single criterion or economic assessments may be quite satisfactory for many business decisions or economic discussions, where the important considerations are to minimise costs and maximise profits in a value adding chain, but increasingly decisions require more complex and diverse elements to be considered (Tsai-Chi Kuo, 2003).

2.7.3 Multi-Criteria Analysis

In the late 1960's and 1970's, decision-making processes started to seek methods which could assess more than the monetary/monetised benefits and costs of projects. This resulted in a move away from single criterion analysis based on monetary-based assessment to Multi-Criteria Analysis (MCA) in which a range of criteria could be considered, which may not have common measures or dimensions against which options could be assessed. The criteria may also be referred to as "measures of effectiveness" and could relate directly or indirectly to the objectives and be quantitative or qualitative. The criteria derived from the economic analyses of previous times could still be incorporated in the analysis, as one or more of the many criteria considered. These assessments looked to explicitly include in the decision-making process issues such as "*the effectiveness of alternative projects, the efficiency of resource allocation, the impact on an equitable distribution of resources and the administrative and legal feasibility of alternative project implementation*." (Meyer and Miller, 1984)

Thus MCA aims "*to identify the best possible alternative (or most plausible ranking of alternatives)*" (Finco & Nijkamp, 1997). In fact this can be taken further to state that it aims to lead to enable a concrete decision, which may not always necessarily be an optimal solution (that is better than all other actions for all the criteria) but one that reflects explicitly and transparently the preferences of the decision-makers and stakeholders inputting to the decision (Schreck, 2002).

> "*Multi-Criteria Decision Making (MCDM) involves a set of alternatives that are evaluated under certain criteria. There are two major classes of MCDM. One is Multi-Attribute Decision Making (MADM) and the other is Multi-Objective Decision Making (MODM). MADM is based on choice from a small set of feasible attributes using decision criteria and priorities. MODM*

> *is designed to deal with feasible attributes bounded from particular constraints. Multiple objectives in MODM are considered simultaneously.*" (Malczewski, 1999)

Thus the assessments can be based on criteria (objectives or attributes) focussed around the general thematic considerations (derived from Meyer and Miller, 1984) of:

- Appropriateness (alignment with community goals, community equity);
- Effectiveness (achievement of desired outcomes);
- Adequacy (relationship/scale of solution to problem, correspondence with expectation of level of issue resolution);
- Efficiency (economic assessment, benefit/cost relationship, incremental benefit/cost);
- Implementation feasibility (fundability, administrative & legal feasibility, organisational capacity to deliver, community resistance and support); and
- Sensitivity (level of response to changing inputs, risk of inadequate/failure of outcome)

The basis of the MCA is therefore the identification of the criteria or objectives to be used in the decision-making process, and deriving measures or scales for each. Each measure or scale must be relevant to the objective or criterion it represents, measurable, sensitive enough to indicate relevant differences between options and able to be understood by decision-makers (Meyer and Miller, 1984). The number of measures should be kept manageable, otherwise decision-makers become unable to contemplate all the factors in balance to make the decision.

The basic process for multi-criteria analysis can be grouped into 4 stages. Initially, the options and criteria to be used are identified. For each criterion, a scoring method or method of measurement is established, which may relate directly to the measure (e.g. noise in dBa) or which may be some relative and non-dimensional scale (e.g. -3 for very poor to +3 for very good). The non-dimensional scale can also be used in mixed qualitative/quantitative criterion assessments, by providing bands or bins that assessed values would be assigned to and a non-dimensional value established (e.g. -3 = >-25%, -2 = -10% to -24%, -1 = 0 to -9%, etc.)

The second stage involves each criterion then being assigned a weighting (perhaps in relation to the scale of the measure being used and the importance of the individual measure compared to the other measures). These first two stages can involve substantial input from the decision-makers and stakeholders.

The third stage involves an assessment being made for each criterion for each option or alternative (filling in the cells of the matrix), and this can be summarised in tabular form, such as shown in Table 2.2 below.

The final stage relates to the decision-makers receiving the outputs of the previous 3 stages and determining a decision regarding the best option or priority of alternatives (it can be tempting at this stage for decision-makers to request a review of the weightings, but that can be seen as compromising the objectivity of the process). However, the framework of the decision-making process requires that the "*decision-maker should still have the freedom to choose alternatives, since he/she has the responsibility for the consequences*" (Schreck, 2002).

Table 2.2 Multi-criteria option summary table format

		Weighting	**Option 1**		**Option 2**		**Option 3**		**Option k**		**Option m**	
			Raw score	Weighted Score	Raw score	Weighted Score	Raw score	Weighted Score	Raw score	Weighted Score	Raw score	Weighted Score
Measure of Effectiveness	MOE 1	W_1	X_{11}	W_1X_{11}	X_{21}	W_1X_{21}	X_{31}	W_1X_{31}	X_{k1}	W_ax	X_{m1}	W_1X_{m1}
	MOE 2	W_2	X_{12}	W_2X_{12}	X_{22}	W_2X_{22}	X_{32}	W_2X_{32}	X_{k2}	W_2X_{k2}	X_{m2}	W_2X_{m2}
	MOE 3	W_3	X_{13}	W_3X_{13}	X_{23}	W_3X_{23}	X_{33}	W_3X_{33}	X_{k3}	W_3X_{k3}	X_{m3}	W_3X_{m3}
	MOE i	W_i	X_{1i}	W_iX_{1i}	X_{2i}	W_iX_{2i}	X_{3i}	W_iX_{3i}	X_{ki}	W_iX_{ki}	X_{mi}	W_iX_{mi}
	MOE n	W_n	X_{1n}	W_nX_{1n}	X_{2n}	W_nX_{2n}	X_{3n}	W_nX_{3n}	X_{kn}	W_nX_{kn}	X_{mn}	W_nX_{mn}
	Total			ΣW_iX_{1i}		ΣW_iX_{2i}		ΣW_iX_{3i}		ΣW_iX_{ki}		ΣW_iX_{mi}

One of the strengths of this method is that the community input can be achieved through determining the weightings of various objectives or criteria and, if a simple assessment scale is used for any methods of effectiveness, then by contributing to the scoring. This allows an understanding by the analyst or decision-maker as to the relative importance that different groups place on the various objectives. Further, different weighting sets can be identified for the various stakeholder groups, from which the analysis can show explicitly whether and how differing outcomes may be desired by the various groups. This could then be taken on to create a selection of sets of weightings using the differing weightings of the various stakeholder groups, to allow the decision-makers a range of information on the impacts of weighting (favouring) the preferences of the stakeholder groups in various ways.

Two paths are then available to the analyst: either create a profile of (weighted) criteria scores for each option or alternative, allowing comparison of option profiles; or to sum the weighted quantitative scores of each criterion to reach a single value for each option.

Another expression of the multi-criteria assessment approach in increasing use recently in local government in New Zealand is the **quadruple bottom line assessment**. This recognises four groupings of objectives being required for assessment to assist with local government decisions which affect communities. These groupings are social, economic, environmental and cultural. Each decision must consider objectives established to provide information related to each of the four "bottom lines".

The **cost-effectiveness approach** relates to how each option or alternative contributes to or achieves the desired community goals and objectives for that decision area or problem and the cost of that option. It is based on a cost-effectiveness ratio being assessed in terms of the overall levels of goal's or objective's achievement per net dollar cost of the option. This allows the decision-makers to consider the trade-offs between effectiveness in achieving the various criteria (measures of effectiveness) and associated cost.

A last approach to be noted related to multi-criteria analysis is the decision-making process for any political decision made by elected officials. Whether or not analytical process and information is presented to elected officials, when a decision is required, some form of explicit or implicit multi-criteria considerations occur. The full range of criteria used and the weightings employed as decisions are made in such circumstances are rarely explicit or obvious to the observer. This informal process is not recommended for significant decisions, nor for transport planning purposes.

The advantages of multi-criteria analysis over the single criterion analysis (economic analysis) include the ability to consider a wide range of criteria, each measured in its own scale. The ability to consider both quantitative and qualitative assessments is a key strength of multi-criteria analysis. Measures of effectiveness can also be created to represent specific interests (e.g. socio-economic distribution of costs or benefits) or geographic areas or impacts that directly or indirectly affect the project. The explicit use of weights for criteria allows the trade-offs between and relative importance of criteria to be clear. It is also simple to undertake sensitivity tests by varying the weightings of the measures of effectiveness, to test how robust the outcomes of the assessment are. A last advantage to note is that multi-criteria analysis allows structured communication with decision-makers (and stakeholders) through the presentation of the scenarios considered through the criteria-option impact matrices (Finco & Nijkamp, 1997).

The disadvantages (or criticisms) of multi-criteria analysis include the (subjective) processes of allocating weights to the various criteria; the scoring process can be subjective and not provide an objective measure of the relative effect of each option; and "*there is no unambiguous way to do this*" (Meyer and Miller, 1984). It is also difficult to ascertain a judgement on value for money between the options. A further disadvantage (which was also noted for the single criterion analysis above) is that multi-criteria analysis can miss geographical or spatial distributions of effects and impacts, unless explicitly considered. This can be a significant issue for decisions related to transport planning matters, given the strong spatial element of all transport infrastructure issues. Another, not explicit disadvantage, is that often many criteria are directly or indirectly related, such as many could be related to economic efficiency, which may lead to unintentional "double counting" in the assessment. A potential disadvantage (or trap of use) is the possibility to add in more and more measures (without necessarily checking internal consistency and logic) leading to potential duplication of criteria.

Weighting and Scoring Methods

A wide range of methodologies exist for multi-criteria analysis, albeit effectively they are variations on a theme. The various methodologies deal with the establishment of weightings and scoring within the matrix itself in various ways. It appears that these variations are driven by the peculiarities of different decision-making processes and the criteria or information involved. However, the application of different methodologies to a decision may yield different results, especially if the output relates to ranking the alternatives rather than identifying the "best" alternative (Finco & Nijkamp, 1997).

The choice of method depends on a range of issues such as objectives of the research, level of the assessment, data requirements and degree of participation by and nature of stakeholders, as well as the consequences of the decision.

Examples of formalised and recognised multi-criteria methodologies are "weighted summation", "multi-attribute utility approach", "ideal point method" and "Electre 1" (all better for quantitative criteria), as well as "permutation method", "Evamix method", "analytical hierarchy process", "outranking methods" (such as "Electre 2") and "regime method" (all better for qualitative criteria) (Finco & Nijkamp, 1997).

There is web based software/freeware for decisions involving analytic problem structuring, multi-criteria evaluation and prioritisation (Web-HIPRE[1]). This may be found at www.hipre.hut.fi (accessed 21 March 2006) and allows creation of private personal working directories as a registered user of the website.

[1] Web-HIPRE is a Java-applet, so is highly portable and accessible. Developed by Hamalainen and Mustajoki at Systems Analysis Laboratory of Helsinki University of Technology, Finland.

Web-HIPRE outlines a range of ways to create weightings, such as:

Direct	Assign personal weightings to each attribute (still totalling to 1.0, or any values and normalise later).
Smart	1. Assign 10 points to the least important attribute (by ranking); 2. Give points (>10) to reflect the importance of the other attributes relative to the least important attribute; 3. Normalise from total score.
Swing	1. Assign 100 points to the most important attribute (Rank = 1); 2. Give points (<100) to reflect the importance of the attribute relative to the most important attribute; 3. Weights normalised from total scores
Analytical Hierarchy Process	1. For each attribute pair, rate by comparison, either verbal (1-9 scale or balanced scale, see Table 2.3 below) or score (1-9); 2. Weighting valued by normalising the row total of matrix against matrix sum.

Other methods for establishing weights include professional judgement, decision-maker judgement, ranking method and the Delphi technique (see appendix 1). Using the first two methods can expose a whole analysis to criticism of not being a robust, repeatable, transparent, objective, or justifiable process.

It is apparent that some methodologies are more appropriate than others to different decision-making situations. For example, the ELECTRE 3 methodology has been criticised as being too complicated, difficult to interpret and without physical interpretation, which would presumably remove it from being useful in any process which wished to involve significant public participation.

Therefore for the purposes of this project which will in all likelihood be developed to input or contribute to proposals in the public arena but with relatively little detailed analytical data, the methodology to be employed must be simple, robust, reliable and understandable, and based on a rating scoring (predominantly qualitative) system.

Due to these requirements and information derived in this literature review, it was decided to further explore and use the Analytical Hierarchy Process (AHP) for this project.

Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) was proposed by Saaty in the 1980's (Saaty, 1990). AHP is based on 3 principles: decomposition, comparative judgements and synthesis of priorities (Tsai-Chi Kuo, 2003). It breaks the decision problem down into a logical arrangement of criteria or inputs and alternatives, and importantly enables a consistent combination of weightings for the criteria to be established for the analysis. It is applicable to decision processes where not all the criteria are quantitative, and a scoring or rating evaluation process is applied to the criteria.

The more factors and stakeholders involved in a decision, the more complex it becomes. In addition, whilst stakeholders may arrive at the same conclusion on a decision, their priorities may differ. Thus a process such as AHP, which allows each segment of a decision to be looked separately, can be useful in allowing stakeholders to examine their priorities and those of others in an ordered and transparent manner, and assess their impacts on the decision and prioritisation process (Elliott & Petrova, 2004)

The process arranges the decision-making process of multi-criteria analysis into a hierarchical structure, starting with the goal of the decision itself as the highest level. A second and successive lower levels the criteria for assessment are identified and the lowest level identifies the alternatives for ranking (see Figure 2.16 and Figure 2.17).

In the following two figures, the process of decomposition of the decision can be observed, starting in each case with the goal of the decision on the left hand side. This is broken into key criteria on which the decision would be made (criteria 1 level), which are then broken into successive layers of subsidiary and progressively more specific criteria (criteria 2, 3, etc.). Links between the goal, the layers of criteria and the choices/alternatives are explicit in the diagram, and assist in the compilation and calculation of weightings of the criteria at the differing levels. The weightings at each criteria level must all total to unity, and allow considerable understanding of the contribution each element makes to the result of the analysis. Scores of individual criterion are only applied for the criteria with direct links to the choices (in Figure 2.16, there are examples of this occurring at each of the three criteria levels). Figure

2.16 is particularly useful in observing the different options and variations of how the linkages may be made.

Figure 2.16 Example of AHP Hierarchy diagram for purchasing a cell phone

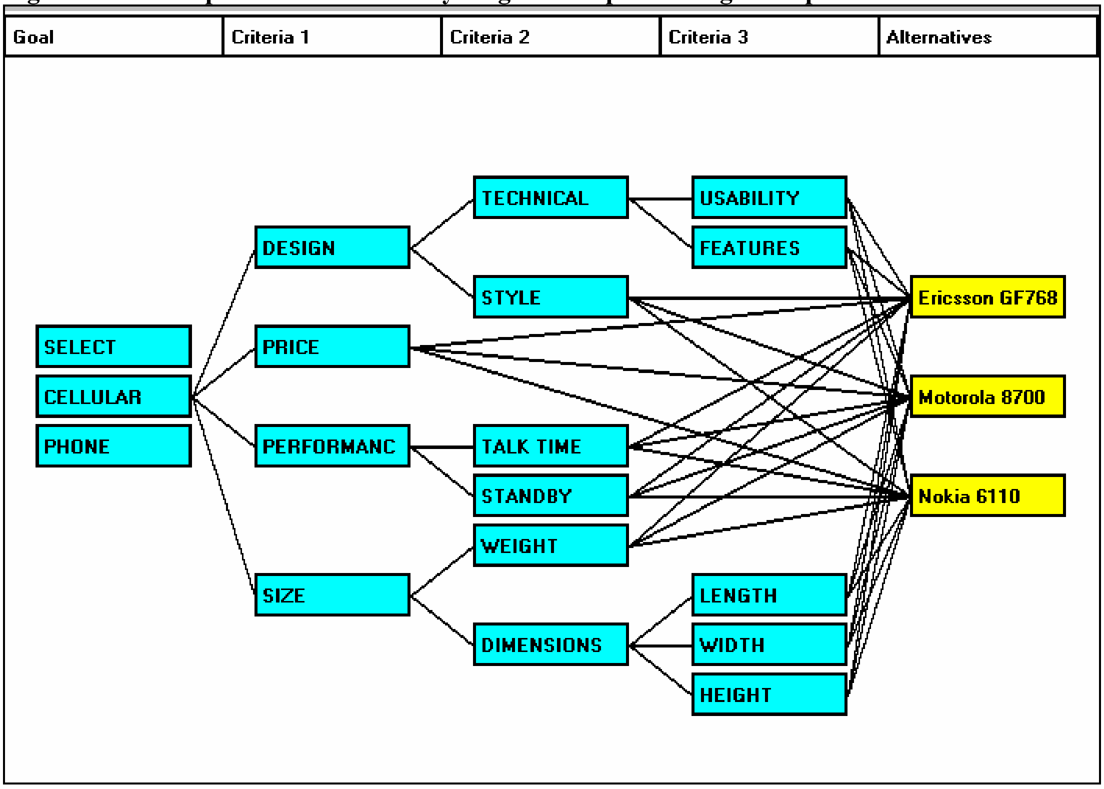
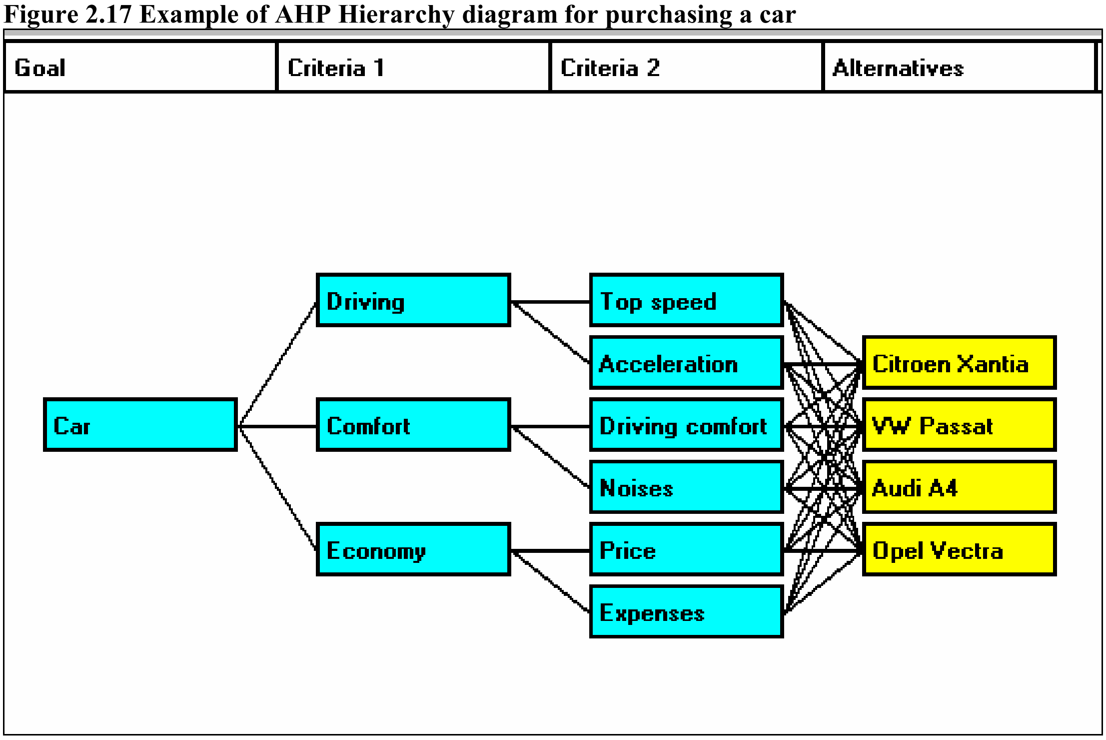


Figure 2.17 Example of AHP Hierarchy diagram for purchasing a car



Weightings are established between the criteria at each level through a pair-wise comparison process. This process requires participants to compare each criterion against all others at a particular level and assign a relative importance or preference score or descriptor, as shown in Table 2.3 below. This descriptor can be particularly useful if wider public participation is sought, given the text based process to assign relative preferences enabled through the descriptors. Concerns by some users regarding what was considered as too much variation in the weightings, particularly with any multiplication effects later in the process, have resulted in an alternative descriptor to score equivalence, shown in Table 2.3 as the "Balanced Scale Score". In either case, AHP has been designed to accommodate human judgement and personal values in a logical manner.

Table 2.3 AHP weighting table

Relative importance/ preference	Descriptor	Balanced Scale Score
1	Equally preferred	1.00
2		
3	Slightly preferred	1.50
4		
5	Strongly preferred	2.33
6		
7	Very strongly preferred	4.00
8		
9	Extremely preferred	9.00

Once the pair-wise comparison is completed, it is summarised in a matrix. It should be noted that each reverse pairing should be the inverse of the initial comparison. The weightings for each criterion are then established by dividing the row total by the matrix sum (the weightings always sum to unity). An example is given in Table 2.4 below, using the 1st level criteria for the car purchase example in Figure 2.17.

Table 2.4 Example pair-wise comparison

	Driving	Comfort	Economy	Row Total	Weighting
Driving	1.00	0.20	9.00	10.20	0.417
Comfort	5.00	1.00	7.00	13.00	0.532
Economy	0.11	0.14	1.0	1.25	0.051
		Matrix Sum		24.45	

For the next level of criteria, the level 2 criteria contributing to each level 1 criterion must have their weighting sum to the level 1 weighting, i.e. the weightings for top speed and acceleration (sub-criteria of "Driving") should sum to 0.417 in the example in Figure 2.17 and Table 2.4. Through this process, a matrix of weights can be formulated, showing the weightings for each criterion as assessed by the different participants and demonstrating their relative preferences and the trade-offs being made.

Benefits of this means of establishing weights is that it is transparent, intuitive and can capture the expertise of practitioners and professionals whilst being able to reduce biases through the potential, valid input of many stakeholders. As noted above, this process also allows contributors to focus on various small components of the problem individually and to gain an appreciation of their contribution to the whole, within a formalised process.

The potential disbenefits or challenges of AHP mainly focus on the conversion of a verbal scale to a numerical scale (taking a value judgement and imposing a numerical interpretation on it). Also the question can be raised of the meaningfulness of the numerical scale if a respondent does not understand the conversion (potentially leading to inconsistency and different interpretations between participants).

Thus the hierarchical structuring of the problem and criteria (attributes or objectives) allows an orderly and structured way of dealing with a decision problem, as well as enabling and testing the consistency of judgements related to priorities of criteria and relativity of weightings.

2.8 Concluding points

Based on this backdrop, the following key findings may be highlighted.

- The key and valuable information available for this project has been found in pieces across a large number of sources, both written and through interviews;

- Park and Ride has been around for many decades in a wide variety of city sizes, types and contexts. Its "success" relates to many factors including system type and size, integration with the local public transport system, being part of a comprehensive transport planning strategy, social and cultural issues, and administrative, legal and cost structures;
- Over time, there has been considerable research and knowledge acquired on operational matters related to Park and Ride;
- There has been almost no research of substance into assessing Park and Ride systems against their system objectives;
- Often the objectives for Park and Ride systems are not clear, if they exist at all. However, a range of Park and Ride objectives used in various locations were identified;
- This lack of research has been at least in part created through the implementation of systems being piecemeal over a number of years;
- There are a wide variety of different types of Park and Ride systems. This variety relates to variations including informal to formal, stand-alone to integrated with the wider public transport system, special event based to permanent, independent initiatives to part of fully integrated transport policy, and based on differing public transport modes. There is evidence of styles and structures trends for Park and Ride between countries;
- There has been no classification system proposed to Park and Ride systems at the system typological level;
- Once implemented, it is unlikely that there would be any significant political or community intentions or pressure to remove Park and Ride systems, due to the systems at least increasing the transport system supply;
- Park and Ride does have its critics, particularly in the UK, who are driven principally by the adverse impacts they perceive of the major parking stations at the periphery of the urban area on the green belt and nearby countryside;
- New Zealand has had Park and Ride systems in place for decades, but historically it has been largely informal or implemented as a relatively low key supportive measure for the public transport system (particularly ferries and commuter rail);
- It is only in the last decade or so in New Zealand that Park and Ride is being considered as a potentially important measure as part of a tool box of techniques

to address growing travel demand and forming part of integrated transport strategies;

- There has been some research and investigations regarding the development and changing structures of urban forms, although there has not been significant interest in this area for many years;
- Around New Zealand, land use planning at strategic level is gaining momentum. These initiatives are seeking to address a range of urban issues including transport;
- It has been possible to identify objectives for urban forms, drawn from the generic urban form focussed geography literature and the individual urban development strategic studies from around New Zealand; and
- Two main initial types of decision-making processes have been identified – the single criterion and the multi-criteria.
- There are a range of means of weighting objectives in multi-criteria decision-making processes, and similarly a range of ways to allow opportunities for stakeholders to participate in decision-making.
- The Analytical Hierarchy Process is a useful process for both weighting and allowing stakeholder participation.

Chapter 3 Proposal of Assessment Framework

3.1 Introduction

It is in this chapter that the key component of this study is presented and explored, that is the Assessment Framework which provides an assessment of the performance of various types of Park and Ride schemes in assisting with the achievement of objectives for various urban forms.

The underlying structure for the assessment framework is outlined, noting the methodology used for both scoring the basic characteristics and the establishment of the weightings between criteria. Sensitivity tests are presented, and the key inputs identified. The information presented on the assessment framework is then used to discuss how to interpret the results.

A key new piece of work proposed here is a classification system for Park and Ride schemes. This describes the types of Park and Ride schemes that exist in terms of their key geographic, operational and strategic characteristics. A similar classification system is proposed for urban forms, for the purposes of this project, which draws upon previous work discussed in the literature review.

The final part of this chapter will consider any strengths, weaknesses and opportunities for improvements that have been discovered in relation to the Assessment Framework and its potential use as a predictive tool.

3.2 Proposed Classification Systems

This section proposes the two classification systems fundamental to the creation of the Assessment Framework that will allow the assessments required to meet the objective of this project. The classification systems proposed will address urban forms at the metropolitan level and Park and Ride systems.

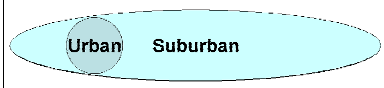
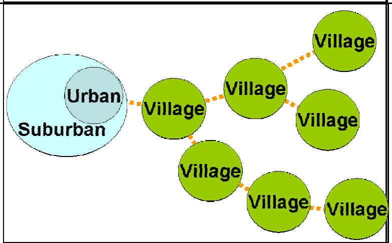
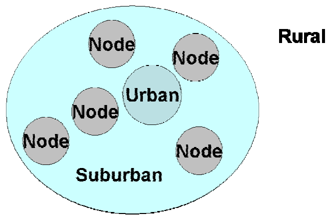
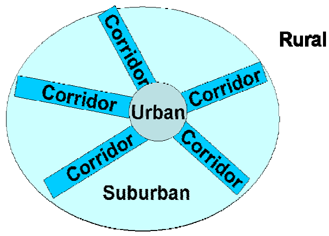
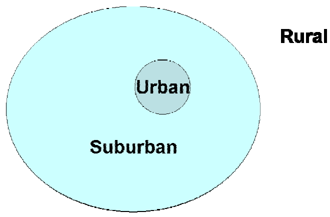
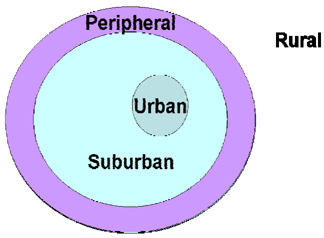
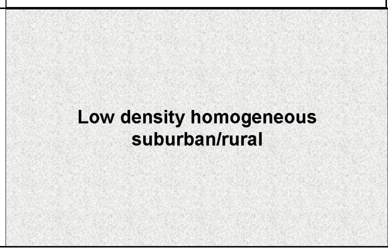
3.2.1 Proposed Urban Form Classification System

The literature review (particularly sections 2.4 Urban Land Use Forms and 2.5 New Zealand Urban Form Planning) is the basis on which this project proposes an urban form classification system for the purposes of this study. The classification system should not have a large number of categories but does need to cover the range of possible alternatives. In that light, the basic structure outlined in Figure 2.7 is a suitable option to adopt and develop. It is a logical arrangement of possible urban forms with a manageable number of options (7) covering the basic urban form types discussed in section 2.4, giving some confidence that the key alternatives are captured. A series of "idealised" conceptual diagrams for each of the types of urban form are presented in Table 3.1, along with a brief description and possible examples.

On seeking to apply the proposed types to real cities, it is apparent that some cities exhibit elements of more than one type, and could possibly be considered as a mixture of types. In such cases, the most appropriate way to deal with the situation would be to divide the urban area into sectors which could then be represented by one of the urban form categories. For example, Wellington may be considered both a radial/concentric - homogeneous city (mono-centric) with linear - nodal corridors.

In relation to the outcomes of this study, an urban area that has been divided into different sectors with different urban form categories could have different types of Park and Ride system introduced in each sector according to the most appropriate Park and Ride type for that sector. Again, using the Wellington situation, the nodal-linear corridors (the Kapiti Coast and the Hutt Valley) are serviced by nodal-rail based park and ride, where as the main Wellington city area has one bus-based park and ride site serving the western suburbs around Karori and Makora.

Table 3.1 Proposed Urban Form Classification System

Type Title & Label	**Concept sketch**	**Description & examples**
Linear - continuous UF 1		Mono-centric city with strong linear corridor(s) of suburban development flowing away from the core Example: Canberra
Linear – nodal/villages UF 2		Mono-centric city with surrounding suburban development and strong linear nodes formed along corridors connected to but outside the main urban area Example: Wellington
Radial/Concentric – Nodal UF 3		Multi-centric city, with or without strong core, and surrounded by more homogeneous suburban development Example: Christchurch
Radial/Concentric - Corridors UF 4		Mono-centric city with strong corridors aligned radially away from the core but still within the urban area, and lower scale/ density suburban development filling between corridors Example: Copenhagen
Radial/Concentric - Homogeneous UF 5		Mono-centric city, having a single core surrounded by essentially homogeneous, lower scale suburban development Example: Hamilton or Dunedin
Radial/Concentric - Peripheral UF 6		The edge city, with strong development activity occurring at the periphery of the urban area with an historic core and general suburban development in between. Example: Irvine, California; Tyson's Corner, Virginia
Dispersed UF 7		A low density urban area, with no strong gradation of activity or centres of higher intensity development. Example: Los Angeles

For the purposes of this project, the outcomes, goals, policies, objectives and principles reviewed and identified are simply being considered and labelled as objectives at varying levels. Based on the literature research material reviewed (such as Auckland Regional Growth Forum, 1999; Joint Western Bay of Plenty Councils, 2004; Greater Christchurch Urban Development Strategy Forum, 2005; Wellington Regional Strategy Forum, 2005), it is being assumed that all objectives identified as used in urban form planning are applicable to all urban forms; it is simply the weighting that varies (even down to a weighting of zero where no influence or consideration of that objective occurs).

The urban form objectives related to transport planning and in particular Park and Ride system have been identified in section 2.5. The degree of emphasis placed on each objective by each of the Urban Form Classification categories (UF 1 to UF 7) is proposed in Table 3.2 below in line with the scoring regime of:

Score	Description
0	No weight or consideration
1	Recognised only, nominal influence
2	Low importance, but assessed
3	Important objective
4	Key driver

This assessment, presented in Table 3.2 below, infers for example that Economic Development is a very important issue for urban forms. In contrast, Energy Efficiency is generally less important overall in decisions considering all these objectives, and would vary according to the type of urban form to which it is considered, to the point where in relation to decisions in the Dispersed Urban Form, it may be only recognised but have only a nominal influence. Some are very simple assessments, such as the "nodal urban form" objective in relation to a Dispersed Urban Form, which are fundamentally misaligned and have no commonality. All outcome level objectives are supported in decisions and visions for all urban form categories. They are sufficiently high level and cover such a range of matters that this is not unexpected. It is the relative importance or weight of outcomes that indicate the key differences.

Table 3.2 Urban Form Category Objectives

	Urban Form Types						
	UF1	**UF2**	**UF3**	**UF4**	**UF5**	**UF6**	**UF7**
Outcomes Objective Level							
Economic development	4	4	4	4	4	3	4
Environmental sustainability	3	3	4	3	3	2	1
Safety	3	3	3	3	3	3	3
Public health & security	2	4	3	2	2	2	2
Accessibility	3	4	4	3	2	2	1
Energy efficiency	2	3	3	3	2	2	1
Social equity	3	3	3	3	3	2	1
General Objectives Level							
Nodal urban form	2	4	4	2	2	1	0
Reduce need for car use	3	4	4	4	3	2	0
Connections, linkages & corridors	2	3	4	4	2	1	0
Manage congestion	3	4	4	4	3	2	3
Walkability	2	4	4	3	2	1	1
Use of environmentally friendly modes	2	3	3	3	2	2	1
Minimise operating costs	3	3	3	3	3	2	3
Improve air quality	3	3	4	2	3	2	3
Minimise noise	2	2	2	2	2	2	0
Adequate provision and efficient use of land	3	4	4	4	3	2	2
Community interaction opportunities	2	4	4	3	2	2	2
Adjust to aging population	1	2	2	3	1	1	0
Specific Objectives Level							
Supports central city	4	3	3	3	4	0	1
Supports suburban nodes	1	2	4	3	1	1	1
Local air quality – Centrally	2	1	3	2	1	0	0
Local air quality – suburban areas	2	2	2	1	2	1	1
Global air quality	2	2	2	3	2	1	1
Local noise - centrally	2	1	2	2	2	0	0
Promote and improve walking centrally	3	2	3	3	3	1	0
Promote and improve walking suburban areas	2	3	3	2	2	1	1
Promote and improve cycling and public transport	3	4	4	4	2	1	1
Minimise vehicle kilometres travelled	3	3	4	4	2	1	0
Increase net regional product	2	2	2	3	2	3	4
Minimise social cost of crashes	3	4	4	4	3	3	3
Minimise fuel and energy use	2	3	4	4	2	2	2
Effective and efficient infrastructure use	3	3	4	4	2	1	1

3.2.2 Proposed Park and Ride Classification System

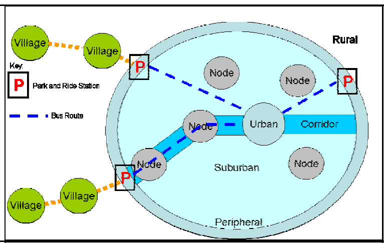
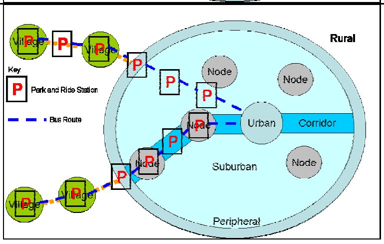
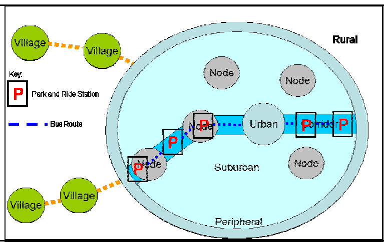
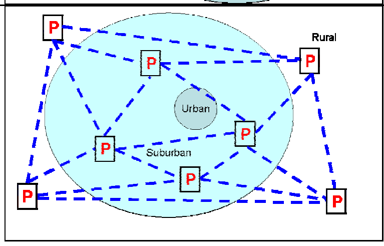
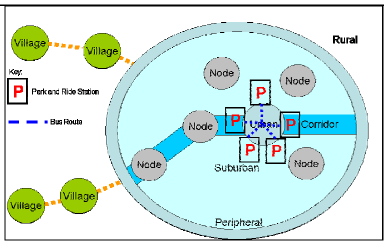
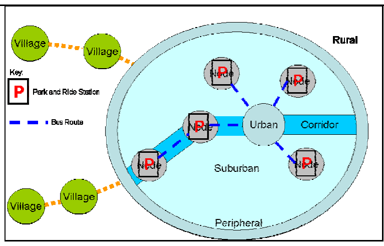
The literature research and discussion with a range of professionals across New Zealand (in Local Authorities and consultancies) has not revealed any known classification systems for Park and Ride systems at a whole system level. There have been some attempts to create localised classification systems to describe individual stations and their role within a system (Young-Jong, *post*-1999; TCRP, 2004). As no Park and Ride classification scheme can be simply adopted for this study, a new one needs to be proposed.

From the information reviewed, three principal key classification variables associated with attempting to classify entire Park and Ride systems have been identified. These key variables relate to geographic distribution of the parking stations, whether the system is integrated with the wider public transport system(s) in the urban area and whether the system forms a part of an implemented package of works and policies that collectively represent a comprehensive transport strategy for an urban area.

In terms of geographic distribution, the systems and information reviewed for this project have given rise to a view that there can be 6 different types of distribution of parking stations within Park and Ride systems, shown in Table 3.3 below (larger versions of these diagrams are shown in Appendix 3). The 6 types relate essentially to:

- The UK style of stations adjacent to the key corridors and at the urban fringe;
- The Parkhurst-proposed (Parkhurst, 2000) Link & Ride system of small scale parking stations along a key bus route or rail line from surrounding villages;
- A sub-set of the Link & Ride, with the stations located entirely within an urban area, but along key public transport corridors;
- The US style of parking stations distribution, created haphazardly (in terms of location) as the community proposes and enables them, along existing bus routes;
- A collar (peripheral parking) arrangement of stations very close into a central city (generally within 1.5 km); and
- A nodal arrangement of stations located at the key nodes or development (retail or entertainment) centres in the suburbs.

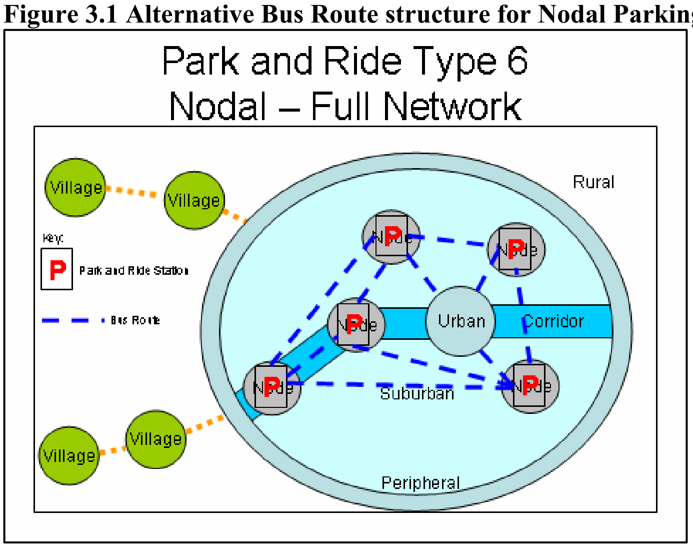
Table 3.3 Park and Ride Distributional Categories

Type Title & Label	**Concept sketch**	**Description**
English or Necklace PR 1		Parking Stations are located at the edge of the urban area, intending to intercept rural and peri-urban traffic at the key entry points to the city; with a centrally focussed bus service.
Link & Ride PR 2		Smaller scale parking stations are placed regularly along existing core bus routes (not necessarily major transport corridors) between outlying villages/key peripheral centres and the city centre. Stations are at least 6-7 km from city centre.
Corridors PR 3		Similar to the Link & Ride, but focuses the stations along key transport corridors and does not provide stations outside the urban area or closer than 6-7 km from city centre.
USA or Dispersed PR 4		Widely dispersed parking stations within and/or outside the urban area, connected by bus services that may or may not be integrated with the wider public transport system, and may or may not focus on the central area.
Collar PR 5		Parking stations are located in a tight ring on or near key entry roads around the central core (less than 1 km). Operates as *de facto* peripheral central city parking. Could be integrated with wider public transport services, but likely to have specific shuttle services.
Urban Nodes PR 6		Parking stations are focussed at key suburban nodes, connected by public transport services that may or may not be integrated with the wider system. Principle focus of public transport services is the central city, but they may also provide connections between nodes

All the conceptual diagrams for parking station distributions have been placed on a generic urban form diagram, to allow differences to be clearly demonstrated. The diagrams also show conceptually the supporting public transport routes associated with the parking stations shown.

However, it should be noted that whilst the basic categories can be applied to bus or rail-based public transport, several of the categories could also have more complex route structures servicing the parking stations that are more possible with bus-based public transport. An example is shown in Figure 3.1, showing the "Nodal" option with services operating between the parking stations around the urban area, as well as routes travelling to the city centre.

Figure 3.1 Alternative Bus Route structure for Nodal Parking Station distribution



Note for clarity: Parking Stations (P) are located at the suburban nodes in this figure.

For simplicity, the proposed classification system will consider the last two variables in terms of either "Yes - Integrated" or "No - Independent", rather than try to create too many sub-variables within those variables. This results in 24 (6 parking station options * 2 "integrated with public transport system" options * 2 "part of implemented transport package" options) combinations or categories from the three key variables.

From the wide range of objectives for Park and Ride systems identified through the literature review and listed in Table 2.1, they can be reduced down to the list of 11 shown below in Table 3.4. This list of objectives is not intended to represent the objectives that are or should be identified for all Park and Ride systems, nor necessarily that they are applicable to all types of system; they are simply the core, most regularly identified objectives. Simplifying these even further, the three most regularly mentioned objectives are cheaper, more effective provision of parking for the central city, reduced congestion on approach roads, and encouragement of public transport use.

Table 3.4 Park and Ride Systems Objectives

Economic Objectives	**Transport Objectives**	**Environmental Objectives**	**Social Objectives**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	Reducing congestion levels on urban radial routes	Reducing local emissions/ pollution levels	Increase social inclusion/ community liveability
More cost-effective provision of parking for central city	Reducing congestion levels in the CBD itself	Reducing transport greenhouse production	
More economically efficient transport system	Reducing the need/pressure for increased road capacity	Reducing other environmental impacts (e.g. noise)	
	Increases public transport use		

The objectives identified in Table 3.4 can be used as the key objectives to be used and focused on in the planning and implementation of Park and Ride systems. As noted above, they will most readily be achieved if the system forms part of a wider integrated transport strategy (a complementary package of works and policies) and is integrated with the wider public transport system.

One of the key assumptions of this project is that transport and land use interact with and impact on each other (Cervero and Seskin, 1995; Banister *et al*, 1997). The interaction is clearly two way, and the main focus of this project is on the impact of Park and Ride systems in achieving the objectives of urban form strategies. However, it should be noted that the degree of achievement of the objectives for any Park and Ride system will also be affected by characteristics of the urban form (e.g. population density, geographic layout, land-use activity mix) within which it is operating. Other variables, such as cultural disposition to mass transit, wealth, legal and administrative structures, may also have some influence insofar as a successful Park and Ride system would increase the *degree* of affect on the urban form objectives. This research project however is not seeking to identify nor quantify those other relationships. Notwithstanding, the influencing factors have affect at the catchment areas level that the Park and Ride system is serving, rather than an entire urban area as a whole.

Table 0.1 to Table 0.6 in Appendix 4 provide a qualitative assessment of the various Park and Ride system categories in terms of meeting the 11 objectives identified above. This assessment is based on a synthesis of the research and literature review undertaken for this project, and is a general overview rather than a definitive, detailed analysis. Clearly, much more information and research into finding specific systems that meet the definitions of each category, along with analysed data from those systems and urban areas is needed to provide in–depth assessment of this matter. The assumption in this assessment is that the Park and Ride system is operating in an integrated environment and that potential demand for the system is able to be satisfied.

3.3 Creation of an Assessment Framework

This section describes the creation of the Assessment Framework and particularly the Assessment Framework Matrix. A general overview of the matrix is provided covering the structure and the formation of the matrix and the populating of the matrix. The focus is predominantly on the particular framework created to deal with the two classification systems proposed in the previous section. However, the method could be generalised to cope with either modifications to these classification systems or the introduction of new typologies.

3.3.1 Matrix of Urban Form types and Park and Ride types

A key output of this project is a matrix of urban form categories and Park and Ride categories, based upon the basic structure shown in Table 3.5 below.

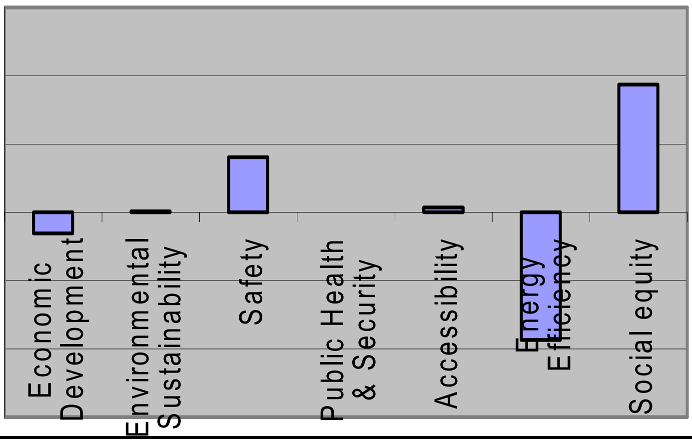
Table 3.5 Basic Structure of Assessment Framework Matrix

		Park and Ride Categories					
		PR 1	PR 2	PR 3	PR 4	PR 5	PR 6
Urban Form Categories	UF 1						
	UF 2						
	UF 3						
	UF 4						
	UF 5						
	UF 6						
	UF 7						

This matrix will show how the various Park and Ride categories perform in and support the various urban form categories, by providing an overall summary score and a graphical representation of achievement of the urban form's high level objectives. The main objective of the matrix is to provide a tool to indicate the relative performance of different Park and Ride system categories in achieving the objectives of different urban form categories (with the assumption of no variation in other influencing variables noted in the previous section, such as cultural responses, wealth, legal and administrative structures).

Figure 3.2 Example Cell from Assessment Framework Matrix

<table>
<tr><td></td><td>Urban Form Type A</td></tr>
<tr><td>Park and Ride

Type I</td><td>Weighted Summary Score = 0.340257

</td></tr>
</table>

In each cell of the matrix (formed from 6 Park and Ride categories against 7 urban form categories), information will be presented in the general format as outlined in Figure 3.2. The weighted summary score provides a comparative, single value assessment from the weighted scores of the performance of the Park and Ride system in that type of urban form (see equation 3.1 below). The vertical scale of the bar graph is relative and non-scalar, and is intended to provide a qualitative perspective on degree of achievement of various urban form objectives.

The Weighted Summary Score (WSS) is calculated using:

$$WSS_{j,k} = \sum_i w_i^j x_i^{j,k} \qquad \textit{Equation 3.1}$$

Where:

$WSS_{j,k}$ = The Weighted Summary Score for Park and Ride category *k* in urban form category *j*

w_i^j = weighting for objective i in urban form category j (informed by data in Table 3.2)

$x_i^{j,k}$ = score for achievement of objective i by Park and Ride system category k in urban form category j environment (informed by information in sections 2.2 and 2.3)

In brief explanation of the results shown above in Figure 3.2, the weighted summary score occurs in a range of -3 to +3, so being near zero (as in the example) indicates that there is overall relatively small benefit to implementing this category of Park and Ride system in this type of urban form. Negative values for the weighted summary score indicate that introducing the Park and Ride category would create more costs than benefits overall to the urban area, where as a positive value indicates an overall benefit.

However in more detail, the profile shows that there would be improvements in the level of achievement of objectives related to safety and social equity for this urban form, but that economic development and energy efficiency would deteriorate in relation to the level of achievement for those objectives if no Park and Ride system of that category was operating. The other three objective areas of environmental sustainability, public health and security and accessibility would see almost no change if that type of Park and Ride system were operating in that urban form. Whilst non-dimensional, the degree of achievement of the objectives can be compared across the objectives. So in this example much more benefit is achieved for social equity than for safety, and similarly much more negative effect would be experienced in the area of energy efficiency compared to economic development.

The purpose of the matrix is to provide a predictive tool in which, from identifying the desired or existing urban form, the relative performance of the various Park and Ride classifications (against the high level urban form transport-related objectives) can be reviewed and a preferred system type chosen for implementation (either from new or in modifying an existing system). This decision could be made either by purely considering the weighted summary scores, or by some comparative process relating the various objective profiles against one another (noting that the objectives are already weighted in the production of the profile). A comparative process may be based upon, for example, either some key threshold(s) below which some objectives should not score, or a set of threshold scores to be achieved in balance to be acceptable.

In all the assessments underlying the matrix, a key assumption is that for each Park and Ride category, the other 2 key variables identified earlier are managed to optimise the systems success. That is, that the system operates as part of a package of transport measures and policies (e.g. related to relative travel times between private vehicles and public transport, system cost structures for users, and managed parking supply); and that the public transport services are integrated to provide a high level of service for all public transport users in the corridor (e.g. minimising abstraction from existing public transport services and cost effective provision of high quality service frequency). In addition for each Urban Form type the other variables which affect a community's response to Park and Ride are held constant across the Park and Ride types.

Other assumptions underlying the assessments contributing to the matrix are that the Park and Ride system capacity can meet the potential demand, that sites are established and operated in an optimal manner to attract users and that urban areas may exhibit more than one urban form category so different Park and Ride categories may be appropriate to different areas of a city or town.

3.3.2 Filling in the Matrix

There are a few steps involved in filling in the matrix. The matrix is filled in cell by cell, from the results of the individualised calculations that underpin each cell. These calculations require data or information related to the linkages between objectives at the different levels, the relative preferences between the objectives at each level and the relative achievement of the level three (most detailed and measurable) objectives for the relevant urban form/Park and Ride category combination. These are described in more detail in the following sections. Although these descriptions are specific to the particular classification systems being used in this project, the process can be generalised.

The basis for the Assessment Framework is a multi-criteria analysis using criteria framed around the objectives identified in the previous chapter for Urban Form, and the analysis is presented in a matrix form for each combination of urban form category and Park and Ride category. Three tiers of urban form objectives are proposed for use in the Assessment Framework, and given the diversity of objectives, a weighting of objectives is proposed. Establishing the weighting involves a process that can allow stakeholder input, although for the purposes of this project, initial weights will be suggested to establish an initial matrix for consideration.

As noted in the previous section, the matrix for this project will cross-tabulate urban form categories with Park and Ride categories, resulting in a 7*6 matrix (42 cells) using the two classification systems proposed in section 3.2. Each cell will be individually filled from the results of the Assessment Framework analysis. This process could be used generically for any combination of classification systems (with appropriate associated objectives or criteria).

Given the general lack of observed data for assessing Park and Ride systems on the basis of system or urban form objectives, this project assigns scores in the Assessment Framework based on a modified 7 point Likert scale[2] (-3 to +3) for the Park and Ride

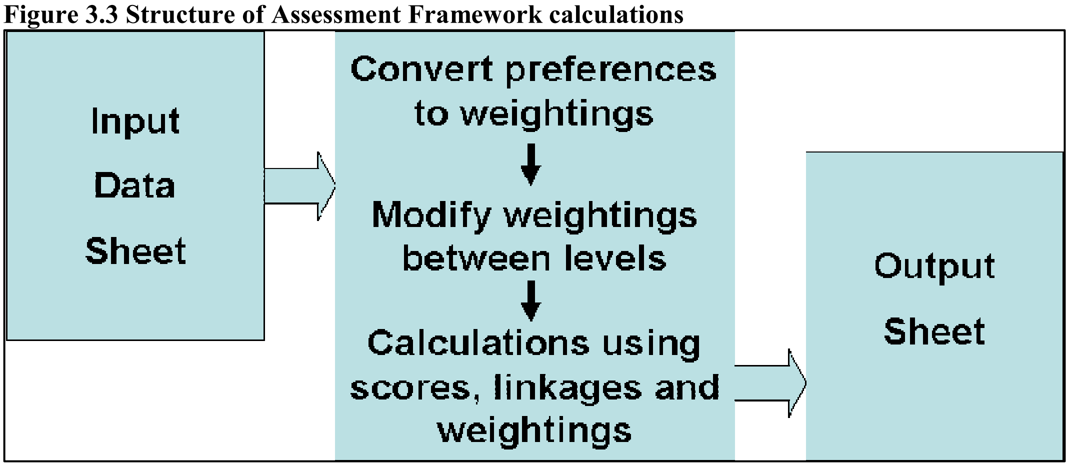
[2] See http://en.wikipedia.org/wiki/Likert_scale

system achievement of objectives and on a modified 9 point Likert/AHP scale (1 to 9) for the weightings formed from descriptions of the level of preference for one objective over another. The underlying assumptions involved in the matrix are covered in the previous section, in later discussions in this section and in section 3.5.

The basis of the information provided in the Assessment Framework Matrix is derived from a spreadsheet[3] based assessment process. The spreadsheet used is a series of 5 interlinking worksheets, as outlined in Figure 3.3: an input sheet, three calculation and data manipulation sheets, and an output sheet.

The input sheet has 3 sections for which data is sought. Information to enable weightings between objectives (or criteria) is entered in the first section based on a standard 9 point AHP scale. Connections or linkages between objectives across the differing levels of objectives is entered in the second section. The last section allows scoring of the Park and Ride system performance in an urban form category, using the usual 7 point Likert scale, slightly modified to be symmetrical about zero. Details of these three inputs are discussed in the outline of the steps below and can be seen in Figure 3.3

Figure 3.3 Structure of Assessment Framework calculations



The first calculation sheet converts the input data into numerical form to allow analysis of the weightings and preferences of the objectives, using AHP. The second

[3] A worksheet is an electronic calculations sheet, and a spreadsheet may be formed by several interlinking or independent worksheets. Example software include Microsoft Excel and Lotus 1-2-3.

calculation sheet then integrates the weightings between the tiers of objectives, to produce "weighted weightings" for the lowest, most detailed objectives level at which Park and Ride systems are scored later. The third calculation sheet uses the weightings and Park and Ride system scores from the input sheet to calculate a weighted summary score for that combination of urban form category and Park and Ride system category. The same sheet also calculates back through the objective tiers to provide a score for each top level objective, contributed to from the Park and Ride system scores. These top level objective scores are then plotted into a bar chart to provide a profile of achievement of top level objectives for that combination of urban form category and Park and Ride system category.

The output sheet is a simple summary recording the urban form and Park and Ride categories being assessed, the weighted summary score and the top level objective achievement profile (bar chart).

Step One: Weightings and AHP

The outputs of the Assessment Framework relate principally to how well a Park and Ride system type contributes to the achievement of the objectives of an urban form category. Therefore, whilst the objectives of a Park and Ride category are important, especially once planning and implementation for it are underway, it is the urban form's transport-related objectives (or those objectives affected by the transport system) on which the assessment must focus.

There are a wide range of transport-related objectives identified in previous sections that are able to be used in this assessment. Some are clearly more important than others, whilst some may have varying importance according to the views of various interests. As a consequence and as a part of the multi-criteria analysis created for this assessment, weightings are to be allocated to each objective at each level. AHP is adopted for use in this assessment to assign weightings and uses the traditional AHP "preference descriptor" to score equivalence scale (noted in Table 2.3 AHP weighting table).

The assessment regime for the AHP objective weightings relies upon descriptions of the relative preferences between all pairings of the objectives at a particular level.

The description options or choices are shown in Table 3.6 and used for filling in a table such as the example in Figure 3.4. In this example, it may be seen that Economic Development is slightly preferred over Energy Efficiency; Accessibility and Social Equity are equally preferred; and Safety is very strongly preferred over Environmental Sustainability.

Table 3.6 AHP Preference indicator

Scale	Descriptor
A	Extremely prefer top row objective
B	Very strongly prefer top row objective
C	Strongly prefer top row objective
D	Slightly prefer top row objective
E	Equally prefer
F	Slightly prefer column objective
G	Strongly prefer column objective
H	Very strongly prefer column objective
I	Extremely prefer column objective

Figure 3.4 Example Objective Preference Assessment

Level One Objective relative preferences

For each of the objectives in the left hand column below, indicate its relative preference in relation to the objective listed in the row across the top of the matrix, using the scale in the table to the left.

	Social equity	Energy Efficiency	Accessibility	Public Health & Security	Safety	Environmental Sustainability	Economic Development
Economic Development	F	F	D	E	C	D	
Environmental Sustainability	D	E	D	C	B		
Safety	F	G	G	E			
Public Health & Security	F	F	G				
Accessibility	E	G					
Energy Efficiency	C						
Social equity							

Example data only

As noted above, for the purposes of this project, initial weightings of the objectives have been produced using this regime for each tier of objectives for each urban form category. It would be very simple for a study to be conducted for a particular urban area and to use the AHP method to produce weightings for that area (or even a series of weightings reflecting the varying views of different stakeholder groups in that area).

Step Two: Linkage Tables

The second set of input data requested in the spreadsheet relates to the linkages between the objectives in successive levels or tiers of objectives. Examples of these linkages are shown graphically in Figure 2.12 and Figure 2.13, and in a slightly different format in Figure 2.16 and Figure 2.17. As indicated in Figure 2.12 and Figure 2.13, the relationships used in this assessment are many-to-many.

For the spreadsheet for this assessment, there are two linkage tables, one for the linkages between level one and two objectives and the other for the linkages between level two and three objectives. The basis of data input in the spreadsheet is that if there is a linkage then a 1 is placed in the appropriate cell in the linkage matrix, and if not a 0 is entered. (This by inference is not seeking to identify the relative strength of the linkages.)

The linkages between objectives are clearer and less open to debate, so it would not be expected that significant stakeholder involvement would be needed in establishing the linkage tables. However, the spreadsheet's input worksheet is set up to enable relatively easy input and modification to the linkage tables used. Linkage tables have been proposed for the purposes of this project, based on the connections shown in Figure 2.12 and Figure 2.13. A linkage table is required for any process using this method if there is more than one level of criteria or objectives. The example linkage table shown in Figure 3.5 is used between level one and two objectives in the Assessment Framework spreadsheets.

Figure 3.5 Example Linkage Table

Linkages between Level One and Level Two Objectives
Indicate the linkages by placing a 1 in the relevant cell in the matrix

	Adjust to aging population	Community interaction opportunities	Adequate provision and efficient use of land	Minimise Noise	Improve Air Quality	Minimise operating costs	Use of Environmentally friendly modes	Walkability	Manage Congestion	Connections, linkages & corridors	Reduce need for car use	Nodal Urban Form
Economic Development	0	0	1	0	0	1	0	1	1	1	1	1
Environmental Sustainability	0	0	0	1	1	0	1	0	1	0	1	1
Safety	1	1	0	0	0	0	1	1	1	1	1	0
Public Health & Security	1	1	0	1	1	0	1	1	0	0	0	1
Accessibility	0	0	1	0	0	1	1	1	1	1	1	1
Energy Efficiency	0	0	0	0	0	0	1	1	1	1	1	1
Social equity	1	1	0	0	0	1	1	1	0	0	1	1

This shows, for example, that there are links from Economic Development to "Adequate provision and efficient use of land", "Minimise operating costs", "Walk-ability", "Manage congestion", 'Connections, linkages & corridors", "Reduce need for car use" and " Nodal urban form".

Step Three: Scoring Level Three Objectives

The final set of input data for each spreadsheet is the scores for how well a Park and Ride category contributes to the achievement of each level three objective. The scoring system used to assign a value to each level three objective, as noted earlier, is a modified Likert scale as follows:

Score	Description
-3	Strongly opposes/obstructs
-2	Opposes/obstructs
-1	Slightly opposes/obstructs
0	Neutral
1	Slightly supports/assists
2	Supports/assists
3	Strongly supports/assists

Figure 3.6 provides an example of a set of scores for a Park and Ride category in an area with particular urban form category. It indicates that the Park and Ride system would provide at least some support for all the objectives being assessed, with all the scores being positive.

Figure 3.6 Example Level 3 Objectives Scoring Table

Level 3 Objectives	Score	Level 3 Objectives	Score
Effective and efficient infrastructure use	3	Promote and improve walking centrally	2
Minimise fuel and energy use	1	Global Air Quality	2
Minimise social cost of crashes	2	Local Noise - Centrally	1
Increase net regional product	1	Local Air Quality – Suburban Areas	1
Minimise vehicle kilometres travelled	2	Local Air Quality – Centrally	1
Promote and improve cycling & public transport	2	Supports suburban nodes	1
Promote and improve walking suburban areas	1	Supports central city	2

3.4 Guide to the Assessment Framework

There are two levels at which the Assessment Framework can be used. Either simply use the Assessment Framework Matrix alone, or create the matrix by using the spreadsheet and creating project specific inputs to the cells in the matrix.

In the first instance, initially establish which urban form category is to be explored through reference to Table 3.1 and its supporting text. With that information, identify by referring to a reliable Assessment Framework Matrix the performance of the various Park and Ride categories, as exemplified in Table 3.7. The Table 3.7 example illustrates that if Urban Form category 5 is to be explored, then all Park and Ride category results in the row for UF 5 would be considered to decide on the most appropriate system type for that urban form type (by whatever decision process is used by the decision-makers).

Table 3.7 Example Assessment Framework Matrix

	Park and Ride category					
Urban Form type	PR 1	PR 2	PR 3	PR 4	PR 5	PR 6
UF 1						
UF 2						
UF 3						
UF 4						
UF 5						
UF 6						
UF 7						

If it is desired to create the matrix specifically for a study, then the spreadsheet will need to be used to establish the contents of each cell in the Assessment Framework Matrix that is needed to be considered. The spreadsheet creates the cell information one cell at a time. However, as each of the seven urban forms can be considered to have the same set of objectives, weights and linkages, then only seven sets of weights and linkages need to be established (rather than individually for every cell – 42 of them). However, each Park and Ride category would perform differently in each urban form category, so 42 sets of scores would be needed to complete all cells in the matrix. Fortunately this is much less onerous than the urban form weighting process and only involves providing 14 scores in each case for the current matrix. As noted in the previous section, it would be unlikely that the linkages tables would require much adjustment, although it is simple to do so.

3.5 Scoring and related assumptions

Generally the scoring for this framework has been undertaken with limited information available from which to derive confident scores. Therefore the scoring has been undertaken using best estimates from the understanding and information garnered from the literature and research accessed for this project, with a primary purpose to illustrate the method and provide an initial Assessment Framework Matrix.

As indicated in the previous section, the most extensive and demanding part of the scoring process used in the spreadsheet to establish the final matrix is the development of the weightings (using the AHP relative preference pair-wise process). It has been assumed in this project that this series of preferences or weightings between objectives remains constant for each urban form category, irrespective of the Park and Ride system proposed for it. As a consequence only 7 sets of weightings (one for each urban form category) are needed. However, this still involved considering 178 pairs of objectives and indicating a relative preference between them for each urban form category. With 7 urban form categories, this involved 1246 comparisons using the 9 types of comparison from extremely preferring objective A over objective B, through to extremely preferring objective B over objective A.

It was found during the process of assigning weightings that some scoring and comparisons became difficult due to the inter-relationships and overlapping definitions or matters that are in common between objectives even when they are at the same level. Further work on definitions may be warranted to reduce this issue if the process is to be used with real world situations and stakeholders.

Similarly it was found that in relation to some objectives (such as air quality), it is extremely likely that different communities even with the same basic urban form would have differing views, definitions, understandings and expectations. For example, a small improvement in air quality in an urban area that already experiences high pollution may not consider it important, whereas for a city with the same urban form but has little air pollution may have a quite different and contrasting perspective. These matters would largely be informed by their experience and history with a particular issue. This infers that even within a particular urban form category that there may well be different weightings for different cities, and that there is not a definitive set of weightings (within some recognised standard deviation) that exist for each urban form category.

In mapping the linkages between objectives in the linkages tables, it has been assumed that the same linkages exist irrespective of the urban form being considered. This also implies (although it is explicitly discussed earlier) that the same set of objectives can be applied to all urban forms and that the differences can be explained through the application of differing weightings for the objectives between the urban form categories. As noted above, the same connections were allocated between objectives as are outlined in Figure 2.12 and Figure 2.13, simply by placing a one in the corresponding cell in the linkage tables. This was a simple, transparent and straightforward process, which can be explored and amended quickly as desired.

Scoring of the Park and Ride categories against the "level 3" objectives was based where necessary, on a comparison between no Park and Ride system in place and having that particular category operating. Again with very little information available on strategic Park and Ride performance, many "best estimates" were required to allow the completion of the initial matrix. Nevertheless, use was made of general commentaries and observations as well as the little analysis that has been made to assist in allocating a qualitative score. None of the assessment categories (level 3 objectives) has had a definitive scoring regime established in this project (e.g. a score of 3 means reduction of 15% in vehicle kilometres travelled and -3 means an increase of 15%, etc.). With the matrix having 42 cells, then 42 sets of Park and Ride performance assessments (against the "level 3" objectives) were required.

In allocating scores in the spreadsheets, it was assumed that (urban activity) corridors enable and promote public transport as well as facilitate access and social equity by providing better mobility by all modes in the least impacting manner. It was also assumed that "nodes" encouraged local travel (by all modes) near those nodes.

For the "Peripheral" urban form, it was assumed that the Park and Ride system could operate in both directions, taking patrons either to the central city or to activities at the edge of the city. This could provide a more efficient system, with less tidal characteristics than systems which are focussed on moving commuters to and from a central city area only.

The "Dispersed" urban form category proved difficult to assign scores, as it is an unusual urban form to understand. It is also an urban form in which it is difficult to get high densities of demand and the implicit nature of Park and Ride systems having a high activity node at one end of the system (the destination end of the public transport journey) proved difficult to apply in that context.

One perspective of the application of Park and Ride in this urban form category is that the stations become at different times both the origins and destinations of the public transport journeys. The easiest Park and Ride category for fitting to and scoring for this urban form was the category which did not have a required central destination associated with it (category PR 4).

In considering the "Dispersed" Park and Ride system, it was noted that the public transport services may or may not pass through the central city area. However, it was scored on the basis that it was more likely than not that public transport services in this type of system would be part of a wider public transport system. Therefore the pre-existing public transport services used by the Park and Ride system would be planned to provide routes to key passenger destinations, such as central cities.

As the scores assigned in this process are non-scalar, the output results are also non-scalar and non-dimensional, and are only appropriate for comparisons between cells in the matrix.

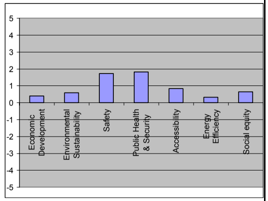
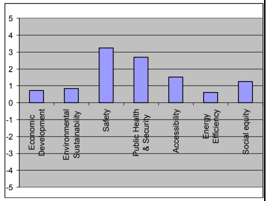
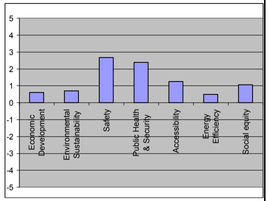
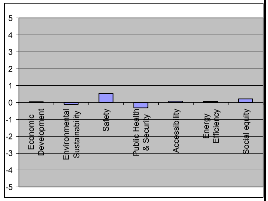
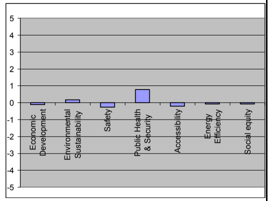
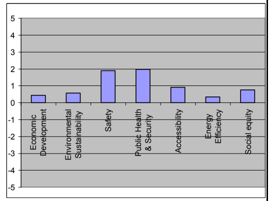
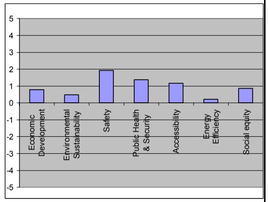
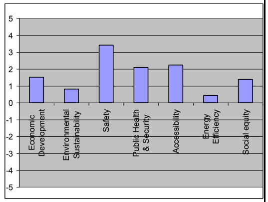
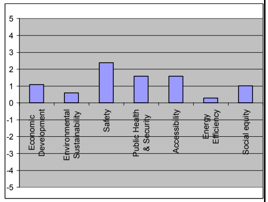
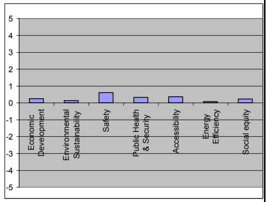
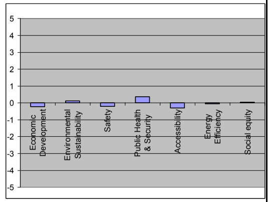
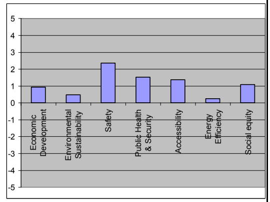
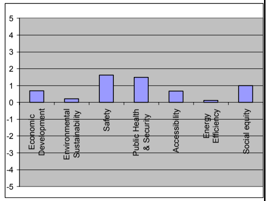
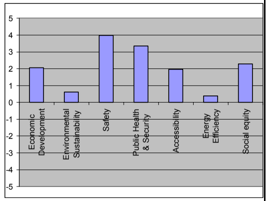
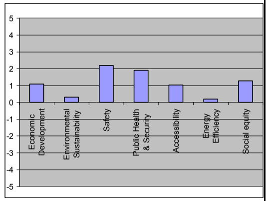
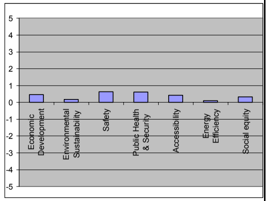
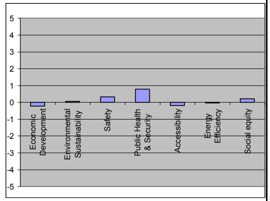
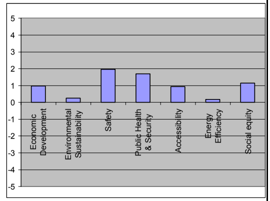
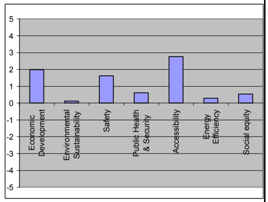
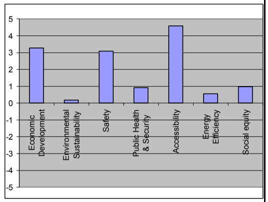
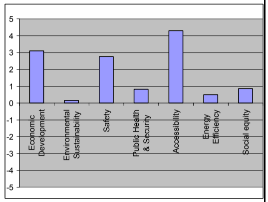
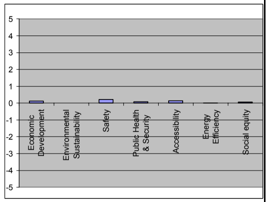
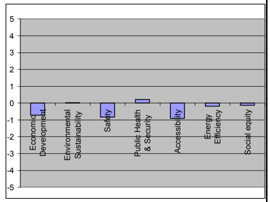
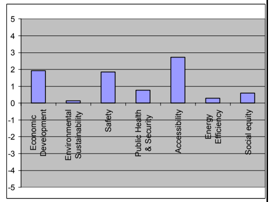
3.6 Initial Results

From the scoring process described in the previous section, 42 sets of assessments were derived and inserted on the Assessment Framework Matrix, shown in Table 3.8. Using this matrix, it is possible to undertake initial checks and "sensible-ness" assessments of the results, which should pick up any counter-intuitive results and allow their exploration. This may reveal errors in any part of the scoring or in the calculation sheets (although initial testing should have removed these already).

It is emphasised that the following discussion on these initial results is preliminary and based upon the initial assessments undertaken as part of this report and not from extensive stakeholder engagement or practitioner and in-depth technical input.

The key and most important result to note initially is that there are differences in performance in achieving objectives between Park and Ride categories for each urban form type.

From the initial results shown in Table 3.8, a number of general trends show up. The order of success in achievement of the objectives is similar for most urban form categories, with Park & Ride category 2 usually performing best, with PR 3 second best, PR 1 & 6 fairly similar next, and PR 4 & 5 not performing well in most urban forms. There are some notable exceptions in the later urban form categories, indicating that the results are not insensitive to the urban form. Reviewing the results in this initial assessment, the question is raised whether Park and Ride should be considered at all in some urban forms. This is particularly so for urban form category 7, and both urban form categories 5 and 6 indicate only low level benefits from the best performing Park and Ride system categories.

Table 3.8 Assessment Framework Predictive Matrix	Park and Ride Category					
Urban Form Category	**PR 1 Necklace**	**PR 2 Link & Ride**	**PR 3 Corridors**	**PR 4 Dispersed**	**PR 5 Collar**	**PR 6 Nodal**
UF 1 **Linear – Continuous**	WSS = 0.882585 	WSS = 1.48485 	WSS = 1.252462 	WSS = 0.108499 	WSS = -0.02326 	WSS = 0.935496 
UF 2 **Linear – Villages/ nodes**	WSS = 0.923013 	WSS = 1.699261 	WSS = 1.195129 	WSS = 0.297729 	WSS = -0.04789 	WSS = 1.034537 
UF 3 **Radial/ Concentric – Nodal**	WSS = 0.816807 	WSS = 2.124998 	WSS = 1.194647 	WSS = 0.392226 	WSS = 0.093703 	WSS = 1.09103 
UF 4 **Radial/ Concentric - Corridors**	WSS = 1.005796 	WSS = 1.692341 	WSS = 1.532278 	WSS = 0.079916 	WSS = -0.20887 	WSS = 1.092932 

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Necklace</td><td>PR 2
Link & Ride</td><td>PR 3
Corridors</td><td>PR 4
Dispersed</td><td>PR 5
Collar</td><td>PR 6
Nodal</td></tr>
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Concentric –
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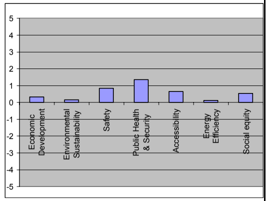
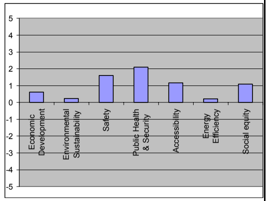
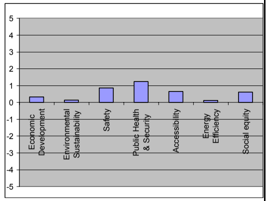
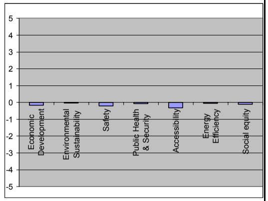
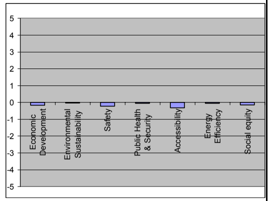
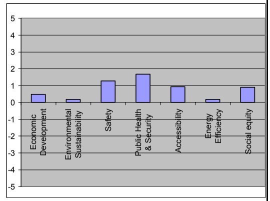
</td><td>WSS = 1.405377
</td><td>WSS = 0.799525
</td><td>WSS = -0.21655
</td><td>WSS = -0.171
</td><td>WSS = 1.124854
</td></tr>
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Concentric –
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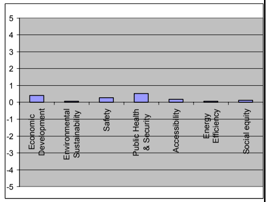
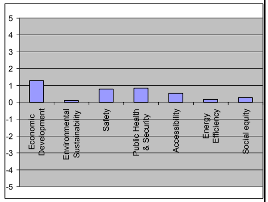
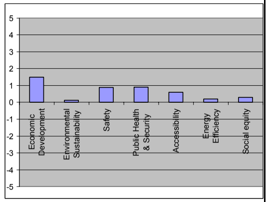
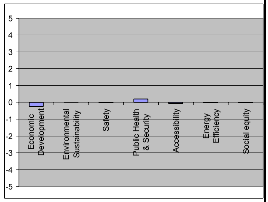
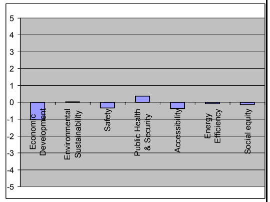
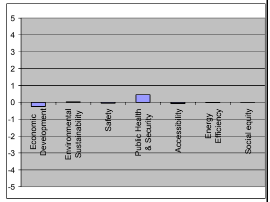
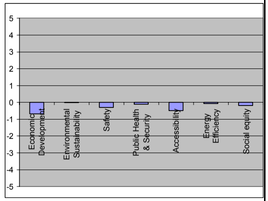
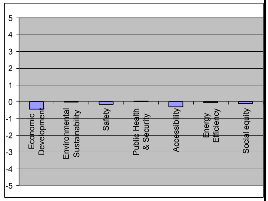
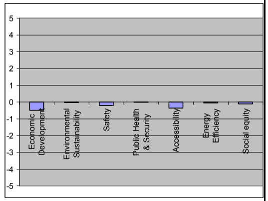
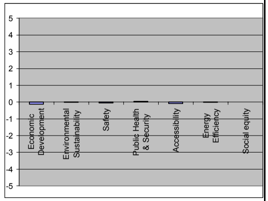
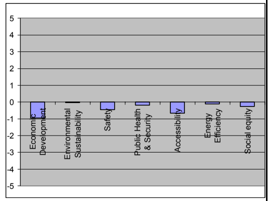
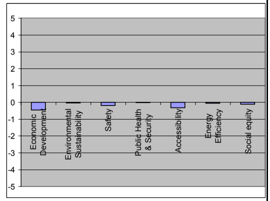
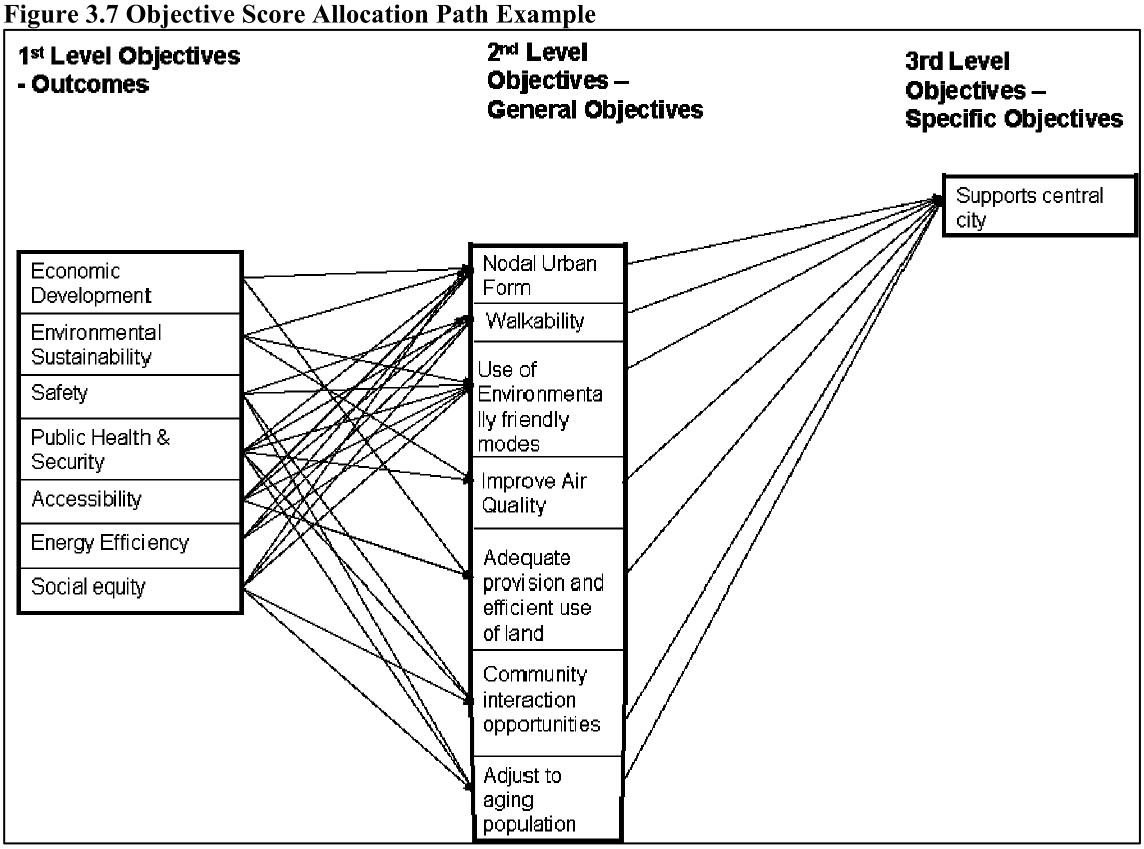
</td><td>WSS = 0.851592
</td><td>WSS = 0.982596
</td><td>WSS = 0.067519
</td><td>WSS = -0.3096
</td><td>WSS = 0.064847
</td></tr>
<tr><td>UF 7

Dispersed</td><td>WSS = -0.36996
</td><td>WSS = -0.14155
</td><td>WSS = -0.22335
</td><td>WSS = -0.00334
</td><td>WSS = -0.56202
</td><td>WSS = -0.19964
</td></tr>
</table>

There is also observable a general correlation between the weighted summary scores (WSS) and the amplitude of the profile graphs, insofar as the higher weighted summary scores also are reflected in generally taller bars across the bar graph, and vice versa. Examples of this situation are seen by comparing across the UF 2 – Linear – Villages category, where the general profile shape expands and contracts in line with the WSS. Irrespective of the Park and Ride category, the middle three indicators are dominant and safety is the largest, and the 2nd and fifth indicators are the lowest with similar values. Similarly, for UF 4 – Radial/Concentric – Corridors, the 1st, 3rd and 5th indicators are dominant and fluctuate in value according to the WSS for the various Park and Ride categories.

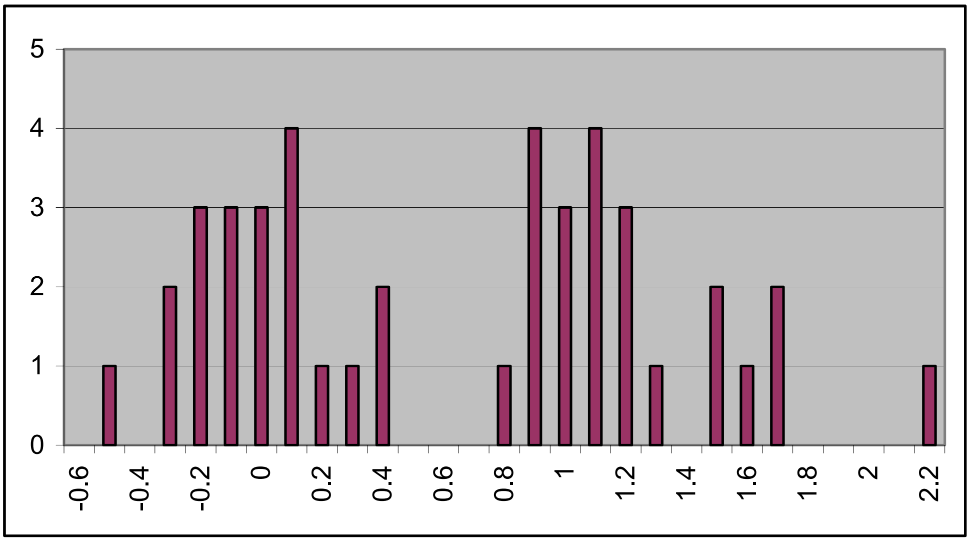
Figure 3.7 Objective Score Allocation Path Example



It may be that this is a result of the large number of linkages or inter-relationships between objectives creating an averaging effect of all the scores across all the profile (level one) objectives. When the spreadsheet is reviewed, it is apparent that each score is spread widely and contributes to all the level one objectives. For example, if the "Supports central city" objective is considered (as shown in Figure 3.7), it can be observed that it splits its score amongst (or contributes to) all level one Outcome objectives by a number of paths through various level two objectives.

The results seen in the initial matrix and shown as a frequency distribution in Figure 3.8, do not show widely varying weighted summary scores (overall range is about 2.7, but excluding two outliers, the range is 2.2). The differences between the various combinations of urban form and Park and Ride categories are more subtle than dramatic in most instances.

Figure 3.8 Frequency distribution of Weighted Summary Scores



The Minimum WSS is -0.562 for the combination of Urban Form UF 7 and Park and Ride PR 5 (or abbreviated to UF 7 – PR 5). The Maximum WSS is 2.125 for UF 3 – PR 2. The frequency distribution shows that the WSS are generally grouped around zero and around 1. With 12 out of 42 possible combinations less than zero (indicating an overall adverse effect from the operation of a Park and Ride system in an urban area), and only 1 less than -0.4, it appears that mostly Park and Ride systems provide benefits to urban areas, with a few exceptions that themselves are not strongly adverse to the priorities and desires of an urban area. No mean or standard deviation of WSS values has been calculated, as an average urban form response is effectively meaningless.

There is one urban form which has all negative WSS values (UF 7 – Dispersed), so in that urban form it would infer that no Park and Ride systems would add net value to the urban area. Conversely, there is one urban form which has all positive WSS values (UF 3 – Radial/Concentric – Nodal), inferring that Park and Ride systems would always provide some net benefit to those types of urban areas.

However, as noted previously, it is the comparison between the results which is the key issue for considerations, and the relative order and proportion still appear intuitively correct and reliable within the constraints of the process.

3.7 Sensitivity Testing

Sensitivity testing is required to check how the Assessment Framework responds to a variety of different scenarios, and to establish how sensitive (how much variation occurs) the results are to changes in the inputs.

The three key areas of inputs to the Assessment Framework are the preferences between objectives which create the weightings for the different objectives (weighting the criteria in the multi-criteria analysis), the linkages between the various levels of objectives and the scores assigned for each Park and Ride category against the level 3 objectives for the urban form categories.

Four sensitivity tests have been undertaken derived from these three areas. Each test modifies only one area to allow comparison with the initial assessment. Two combinations of urban form and Park and Ride category were chosen against which to have the four sensitivity tests applied. They were chosen on the principles of reasonably likely combinations to be interesting to stakeholders, and that in the initial assessments, one showed strong amplitude and varied profile with a relatively high weighted summary score whereas the second showed a small amplitude with some negative scores and a low weighted summary score. Thus the two chosen were UF 3: "Radial/ Concentric – Nodal" versus PR 2: "Link & Ride" (the more defined output combination) and UF 2: "Linear – Villages/nodes" versus PR 5: "Collar" (the low response combination).

The sensitivity tests used are:

- **Extreme weights**: The assigned preferences are all assigned the "extreme preference" value in the direction of the initial (base) assessment. For initial assessments of equal preference, the equal preference was retained. So any preference which was in the initial assessment scored as "A" (extremely prefer the top row objective) through to "D" (slightly prefer the top row objective) was re-scored as "A", and any preference scored as "F" (slightly prefer the column objective) through to "I" (extremely prefer the column objective) was re-scored as "I". The numerical values of each pair-wise comparison were then 9, 1, or 0.1111.

- **Simplified Linkages**: The two linkage tables are considerably simplified so that there are significantly fewer linkages between objectives at different levels (see Figure 3.9 and Figure 3.10 in contrast to Figure 2.12 and Figure 2.13). The number of linkages were reduced to a maximum of four from each level one objective and three from each level two objective.

Figure 3.9 Simplified Level One-Two Linkage Table for Sensitivity Test

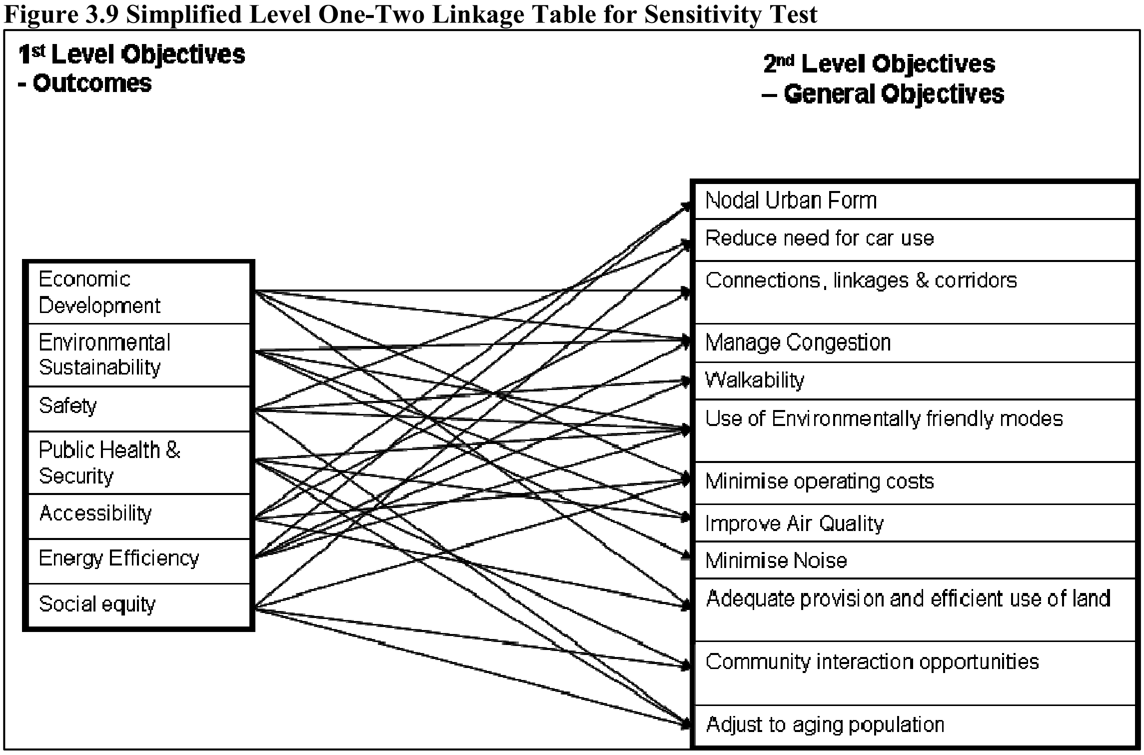
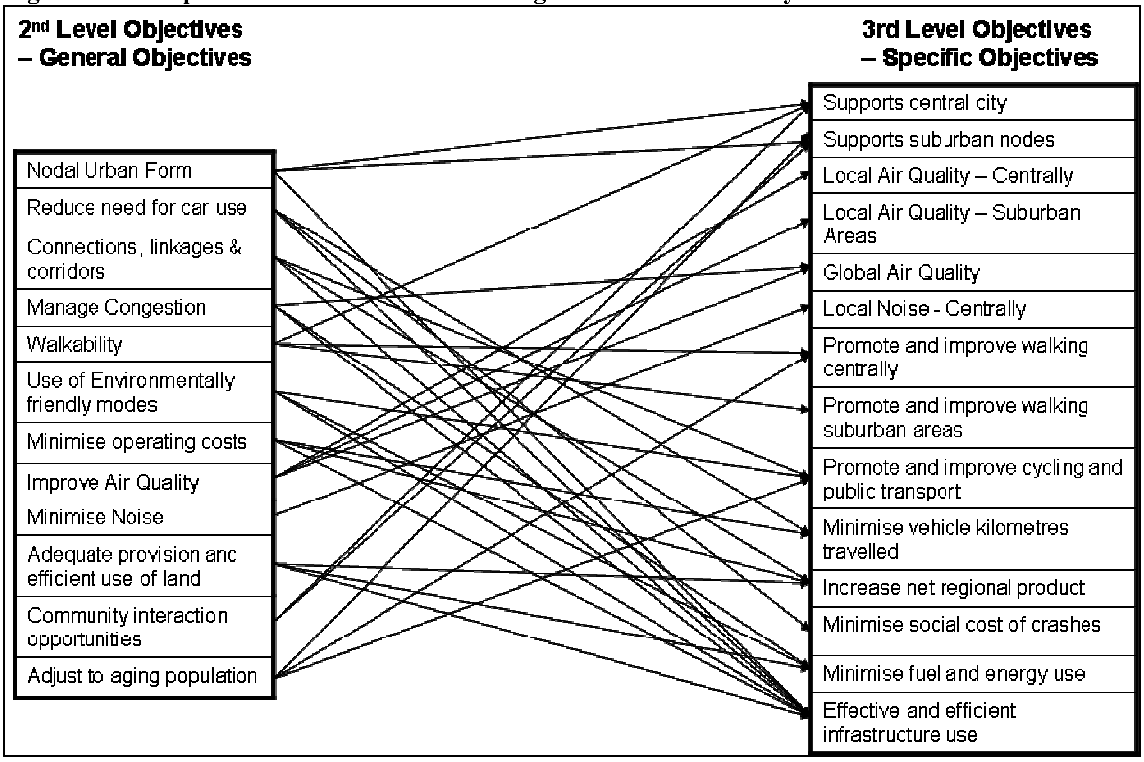


Figure 3.10 Simplified Level Two-Three Linkage Table for Sensitivity Test

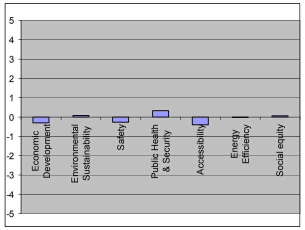
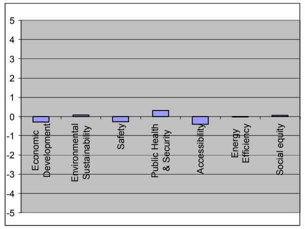
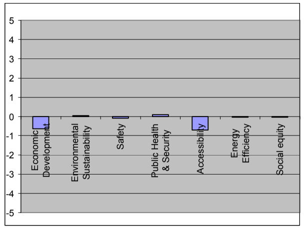
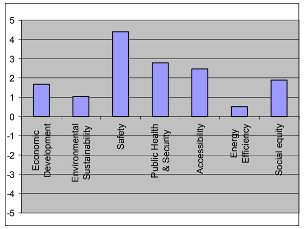
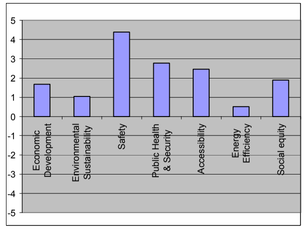
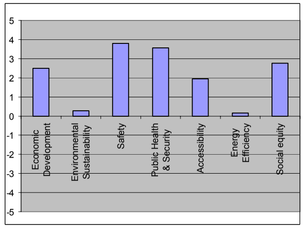
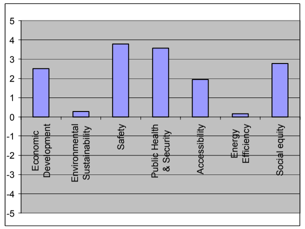
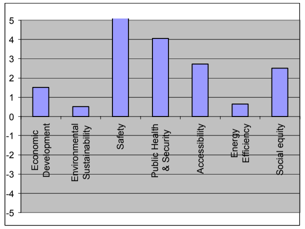
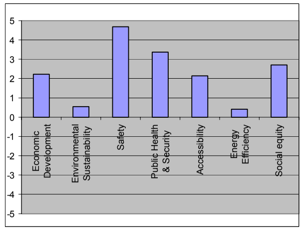
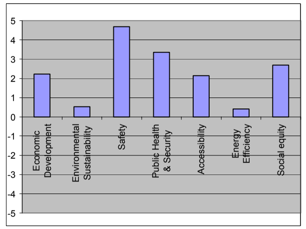


- **Extreme Scores**: The scores assigned against the level three objectives (in the initial assessments based on -3 to +3) are all assigned a value of +3.

- **Important Scores**: The level three objectives are ordered by their weightings and the highest 50% are assigned a value of (scored at) 3 and the lowest 50% are assigned a value of (scored at) 0.

The outcomes of these sensitivity tests are presented in Table 3.9, in the same basic format as the Assessment Framework Matrix. The sensitivity test results in Table 3.9 show that the influence of the strength of the weights assigned has relatively little effect on the final profile and weighted summary score, so long as the direction of the expressed weights is the same. The weighted summary score varied by around 2-3% and each profile indicator maintained the same direction and similar quantum. This indicates that any concerns regarding tending to the centre in assigning preferences can largely be set aside, and/or that the preference scoring scale could perhaps be reduced in breadth (say to a 7 point scale rather than a 9 point scale).

Table 3.9 Sensitivity Test Results Matrix

	Sensitivity Test Scenarios				
Base Category Combination	**Base Results**	**Extreme Weights**	**Simplified Linkages**	**Extreme Scores**	**Important Scores**
UF 2 Linear – Villages/ nodes **PR 5 Collar**	WSS = -0.06841 	WSS = -0.06841 	WSS = -0.25393 	WSS = 3 	WSS = 2.160912 
UF 3 Radial/ Concentric – Nodal **PR 2 Link & Ride**	WSS = 2.152784 	WSS = 2.152784 	WSS = 2.2241292.224129 	WSS = 3 	WSS = 2.31505 

Simplifying the linkage tables had more effect than modifying the weights (although changing the linkages did obviously affect the weightings). Overall it produced stronger responses in various profile indicators, although whilst some indicators increased, others decreased and yet others remained relatively unchanged – no obvious pattern emerges when comparing the two category combination tests. The stronger response overall is reflected in greater absolute values for the weighted summary scores. It may be suggested from this test that having too many linkages does create an averaging effect on the final profile result.

The allocation of extreme scores clearly shows that the score allocated to the level three objectives is the most influential part of the assessment process. By far the greatest response occurred in this test, with some profile indicators exceeding the top value on the y-axis. The effect on the UF3 - PR2 combination which already had quite high scores was not as pronounced as that on UF2 – PR5 which in the initial assessment had quite low (and some negative) scores. The profile for the UF3 - PR2 combination essentially remained the same shape but was amplified further, as the initial assessment contained all positive values which were simply increased. The profile of the other combination was markedly changed as the scores in the test were not cancelling each other out, which occurred in the initial assessment when some negative values occurred. The weighted summary score is not useful in this test (except as a sum check of all the weighting calculations), as it reflects the assigned score of 3 given to all elements.

The important scores test shows that given the weightings used, 50% of the scores (allocated to the higher weighted objectives) affect 70-80% of the final outcome. With this level of impact on the final results, it is logical (and confirms the intuitive proposition) that in trying to gain confidence in the results, effort and focus should be applied to data related to those more highly weighted objectives rather than the remaining 50% which contribute relatively little to the final result. The level of effect in this test would be determined by the spread of weights, so if all weights were equal then 50% of scores would contribute 50% to the final result but as the weights become more varied, then the level of focus on specific objectives data and information should increase.

3.8 Initial strengths and weaknesses observed

The key and obvious weakness of the Assessment Framework in terms of its application to real world situations currently is the lack of useful data to use in the formulation of the Assessment Framework Matrix. This is especially so in terms of factual and consistently based data and analysis related to the objectives of different Park and Ride systems at the system level.

This can be remedied to some extent in the area of the weightings, by involving stakeholders of a particular urban form category in a weighting exercise, even if that exercise is only to consider that particular urban form category. Such community and stakeholder input could potentially re-shape the outputs and results shown in the project matrix quite considerably. This is a relatively simple exercise to undertake with a set of stakeholders for an urban form category, which can be seen as a strength of the process. The more challenging matter would be accessing stakeholder groups from each of the urban form categories.

Improving or confirming the relative preferences contributing to the weightings would considerably improve the confidence in which the Assessment Framework Matrix could be held, given the impact that they have in the results. Whilst the actual strength of the preference may not have a strong influence of the outcomes (demonstrated in the extreme weightings sensitivity test), the direction of the preference does appear to influence the outcomes and certainly would affect public perception of the validity of the results.

In compiling the spreadsheets for the Assessment Framework, there is a considerable amount of work required to fill in the preferences tables for the three levels of objectives. This degree of input may be a disincentive to public or stakeholder contribution to develop the Assessment Framework for a specific project or location.

Not having congestion listed as a level three objective on which scores could be given may be perceived by stakeholders as a disappointment, especially as many proponents of Park and Ride systems consider it as a key justification for its implementation and hold significant hopes for the congestion relief that a Park and Ride system would provide. Nevertheless, effects of congestion are covered and contributed to by several subsidiary objectives in the Assessment Framework, and it is this impact of congestion on many other indicators (or lower level objectives) that justify its placement in the second tier of objectives. Notwithstanding this, it is important that contributors to a weighting and scoring process understand the connections and contributions (perhaps via guidelines), to avoid double counting and to assist an improved appreciation of the wider objectives and effects of Park and Ride systems.

The basic sense and intuitive nature of the results in Table 3.8, especially in relation to one another, gives confidence about the basic process and can be seen as a strength of the methodology. As the Assessment Framework Matrix does show considerable variation between the results in the various cells, it does show that the choice of Park and Ride system category can affect the achievement of objectives for an urban form. It also indicates that the matrix could be used as a predictive tool insofar as indicating how Park and Ride systems categories could perform relative to one another in a particular situation or location. Notwithstanding this, the non-scalar, non-dimensional nature of the results does not give an indication of the degree of impact.

The format of the results shown in the initial results matrix are as anticipated in the methodology, providing both a simple summary score as well as a profile. Having both sets of information is seen as a strength of the methodology for decision-makers to better appreciate the effects of the options and make more discerning decisions.

The sensitivity testing showed clearly that the scores allocated to how well the Park and Ride system categories achieved the level three objectives were important to the final results. This was important to achieve, because if the scores for achieving the objectives did not affect the final results, then the Assessment Framework would not provide any valuable assistance to decisions related to choosing a Park and Ride system classification for an urban area.

The sensitivity testing also showed that care is needed in managing the linkage tables, as too many linkages between objectives can result in averaged results showing little differentiation between profile indicators and reduces the value of having a profile. Too many linkages would tend to drive decisions based more strongly on the weighted summary score alone, as the profile would contribute little useful information to the decision makers in terms of differences between options.

3.9 Concluding points

Based on the material presented in this chapter, the following key points can be highlighted:

- From earlier information presented in this project, two classification systems were adopted for use in the Assessment Framework: one for urban form categories and the other for Park and Ride system categories;
- The urban form classification system adopted was that proposed by Thomson and outlined in Chapter two. As no classification system has been discovered for Park and Ride systems at the system level, a classification scheme was proposed developing from some earlier work by Young-Jong (1999) and TCRP (2004). Some detail in terms of descriptions and objectives were provided for each classification system. The Park and Ride system categories were assessed qualitatively against a reduced list of 11 key objectives for Park and Ride systems;
- It was noted that the application of the classifications systems to the real world would not be a simple or pure task, and may require some discretion and artistry;
- The Park and Ride system classification process recognised three key variables on which Park and Ride systems could be defined: geographic distribution of parking stations, integration with the wider public transport system and being part of a package of complementary, implemented transport policy and infrastructure. For the purposes of assessments in this project, the later two variables were assumed to be in optimal state for the successful operation of the Park and Ride system in each circumstance, and that the community-based variables were held constant for each urban form in the matrix;
- The Assessment Framework methodology was presented, with the Assessment Framework Matrix as the key final output, supported by a spreadsheet analytical tool. The matrix provided information/results on the possible combinations of

urban form and Park and Ride categories (in 42 cells), with the results shown as a weighted summary score (from a multi-criteria analysis) and a profile of the level of achievement of high level objectives. The framework is set up to enable significant input from stakeholders in the areas of weightings (through expressions of relative preferences between objectives) and the assignment of scores for the Park and Ride system categories against the lowest level objectives;

- Discussion was presented on the basis and assumptions involved in inputting scores to the Assessment Framework to provide an initial set of results. Key amongst the issues involved is the lack of good and accessible information to guide the scoring process. It was identified that given the lack of information, more input from other stakeholders and/or professionals and practitioners would provide more confidence in a final matrix. The scoring process also revealed that there were some unusual and non-traditional combinations which had to be considered in the scoring process. These combinations present a considerable challenge to score. Part of this challenge could be addressed through the further definition of some objectives, to reduce potential confusion over interpretations of what each is covering;
- Results have been presented from the initial assessment, along with comments drawn from a preliminary review of these results. Generally certain categories of Park and Ride systems perform better than others in most urban forms, especially the “Link and Ride” and “Corridor” categories. Some urban forms do not appear to provide fertile ground for the operation of Park and Ride systems. There appears to be a correlation between the amplitude of the results profile graph and the weighted summary score for each urban form/Park and Ride combination;
- Sensitivity tests were proposed and results presented, based on 4 scenario options being applied to 2 urban form/Park and Ride combinations. These indicated that the scoring of Park and Ride system performance against the level three objectives was a highly sensitive input to the assessment. The strength of preference between objectives and the number of linkages between objectives were much less influential on the final results, although a lower number of linkages allows better delineation between the individual profile indicators in the Assessment Framework Matrix;

- An overview of key strengths and weaknesses of the Assessment Framework observed in the work done to date has been provided. This highlights that the key weakness to date relates to the lack of reliable and extensive information from which to derive scores at most points in the spreadsheet. However, the Assessment Framework is easily comprehensible and has been set up to allow ready input from stakeholders and/or practitioners, which would potentially add value and confidence to the results. Currently the Assessment Framework requires a considerable amount of input to the establishment of the preferences and weightings of the objectives, which was shown through the sensitivity testing to have room for simplification; and
- The work done to date indicates that the Assessment Framework matrix could be used as a predictive tool insofar as indicating how Park and Ride systems categories could perform relative to one another in a particular situation or location.

Chapter 4 Assessing Framework against real cities data

This chapter outlines an assessment process in which a series of real world cities are checked against the initial Assessment Framework Matrix presented in the previous chapter (see section 3.2 and Table 3.8). The purpose and rationale for the testing is outlined, followed by the presentation of basic required data from the six cities used in this assessment. The cities are individually assessed against the matrix and discussion presented on how the cities achievement of objectives is assisted by their Park and Ride systems. A series of observations from this testing are made at the end of the chapter.

4.1 Purpose of testing

The principal purpose of testing the matrix against real cities is to establish whether the information provided in it is robust and reliable enough to be able to place confidence in the matrix for decision-making. A successful exercise would provide a degree of assurance that the matrix is auditable and fit for the purposes of making recommendations about the relative performance of various Park and Ride system types in various locations. In effect, this would be a type of validation exercise, to use transport modelling terminology. If the matrix is shown to be inadequate or deficient in some way, then a "re-calibration" of the matrix (a review involving re-calculating the background spreadsheets and inputs for the problem areas) would be needed.

It is not intended in this exercise that a fully comprehensive test is conducted. This would require information for every cell (42 cells) in the Assessment Framework Matrix, which would look at before and after information (or compare similar cities with and without Park and Ride systems). That would not be feasible, and is beyond the scope of this project. Rather, testing against real city data is intended to act as a number of "spot checks" to assess whether the matrix appears to be consistent with the information in hand.

4.2 Test data

The data needed for this testing are the urban form category into which the city (area) falls, the Park and Ride system category and the impacts or success that the Park and Ride system is experiencing in meeting the city's objectives.

Unfortunately, as noted in the literature review, there is very limited published information that has been discovered covering the latter needed data, i.e. there is incomplete information published as to what each city's objectives are, or their relative importance. Limited information has been sourced for this exercise from Auckland, Wellington, Shrewsbury (UK), Oxford (UK), Houston (Texas, USA) and Portland (Oregon, USA), as follows:

4.2.1 Auckland

This assessment will consider the recently opened Auckland Busway system. The urban form category for this area of Auckland affected is considered, on balance, linear – continuous, although with Albany at the northern end of North Shore City, Takapuna near the south and the Link Drive commercial centre, there are aspects of the villages/nodal urban form present. The Busway Park and Ride system can be considered to be a Type 3 (Corridor system) (see Table 3.3), with its series of parking stations located adjacent to the Northern Motorway, north of the Harbour Bridge.

There are no discovered expressed priorities of the key outcomes (level one land-use objectives) for Auckland. Nevertheless, from information promoted by Auckland Councils associated with the Regional Land Transport Strategy, the Auckland Busway project and the Auckland Joint Officers Group work (from which considerable Government-sourced "Crown funding" has been allocated to Auckland for transport improvement projects), there has been considerable emphasis placed on the economic and safety impacts of the poor performance of the transport system, with lesser but some concern regarding accessibility and environmental effects. The Auckland transport system, as with all New Zealand, needs to develop in line with the five objectives of the New Zealand Transport Strategy[4] to maximise opportunities for central government subsidy funding for projects. Therefore for this project, it is proposed that primary emphasis may be assigned to Economic Development, Safety and Public Health & Security, with secondary emphasis on Accessibility and Environmental Sustainability.

Since opening its first two parking stations, the Busway has been very well subscribed and parking spaces are fully occupied from the morning peak demand. However there is little data available to assess the effects of its use, such as in terms of number of vehicles removed from using the Northern Motorway, or additional person-trips being made to the central city.

4.2.2 Wellington

This assessment will consider the Wellington rail-system based Park and Ride operation. The urban form category for this area of Wellington is linear – villages/nodal, when considering the main rail corridors, either on the Kapiti Coast with settlements serviced up to Paraparaumu, and the Wairarapa with nodes through the Hutt Valley, then through Wairarapa up to Masterton.

This rail-system can be considered a Type 2 (Link and Ride system) (see Table 3.3), with its series of stations located in both urban corridors in Wellington metropolitan area and extending into adjacent townships beyond.

There are no discovered expressed priorities of the key outcomes (level one land-use objectives) for Wellington. Nevertheless, from information presented in the Wellington Regional Land Transport Strategy and the Wellington Regional Strategy website, there has been considerable emphasis placed on impacts to objectives for the regional economic performance and accessibility to the central city, with lesser but some concern regarding safety and environmental effects. As with Auckland (see previous sub-section), Wellington must fully consider the New Zealand Transport

[4] The five objectives of the New Zealand Transport Strategy are Economic Development, Safety & Personal Security, Access and Mobility, Public Health, and Environmental Sustainability

Strategy objectives in any improvements to and operations of its transport system if it wishes to apply for government subsidy funding. Therefore for this project, it is proposed that primary emphasis may be assigned to Economic Development and Accessibility, with secondary emphasis on Safety, Public Health & Security and Environmental Sustainability.

Recent media releases (Greater Wellington, 2006) have stated that the car parking facilities at the rail stations are full and overflowing, and have encouraged commuters to access the rail stations by foot or feeder bus services rather than car. There are some 4000 official spaces, but considerably more cars are parking at many stations than the nominal capacity (Porirua provides 300 spaces, but has over 700 cars parking there). This has been a recent development, following on from increases to the rail services provided along the corridors.

4.2.3 Shrewsbury

This assessment considers the 3 station bus-based Park and Ride system operating in Shrewsbury, in Shropshire (Surl, 2005). The urban form for Shrewsbury is radial – homogeneous, in line with the urban form of many traditional English towns, having an historic centre and growing suburban areas surrounding it, with an edge of town ring-road/bypass system. There is anecdotally not a significant commuting demand from outside the city's boundary. This bus-based Park and Ride system is the traditional English Type 1 (Necklace) system (see Table 3.3), with its 3 parking stations located near the ring road and near the key arterial routes into the town.

There are no discovered expressed priorities of the key outcomes (level one land-use objectives) for Shrewsbury. However, information on the Park and Ride system for Shrewsbury (Surl, 2005) notes that the aims for the Shrewsbury system are "*to improve the accessibility of Shrewsbury for people in ways that do not increase dependence on the private car, and to make Shrewsbury as safe as possible in ways* *which respect and enhance its historic character.*”[5] This would indicate that emphasis could be assigned to Accessibility, Safety and Environmental Sustainability, with secondary emphasis on Economic Development and Personal Health & Security.

The system provides some 1,992 parking spaces, and presently carries about 5% of travellers to the town centre (noting that 45-50% of trips are by car and about a third are by foot). About two thirds of the Park and Ride trips are for shopping purposes (the primary focus of the system when introduced) and the remainder are evenly split between tourism and work/commute purposes, and over two thirds of patrons are over 50 years old (who get discounted fares).

4.2.4 Oxford

Oxford is essentially the same as Shrewsbury in terms of urban form and Park and Ride system. Its system is larger with 5 stations providing about 5000 parking spaces (Oxfordshire County Council, 2002). The priorities for Oxford are assumed to be the same as for Shrewsbury, as it has for many years sought to protect its historic centre from the adverse effects of traffic whilst maintaining high quality accessibility and safety. Oxford’s integrated transport strategy appears to be having an effect (despite having very limited bus priority for any services), with decreasing person-trip mode split for cars and taxis entering the town centre, estimated in 2001 at 34% and increasing public transport use (including the Park and Ride patronage), estimated in 2001 at 37%. An estimate of the Park and Ride mode split is 6-7% of person trips entering the town centre (including walking trips).

4.2.5 Houston

This assessment will consider the High Occupancy Vehicle (HOV) Lane Park-and-Ride facilities in the Houston area (TCRP, 2004). The Houston Metropolitan area has a population of around 3 million people, and is characterised by a low density

[5] The most interesting conclusion of the Surl review is that “P&R probably does not directly stimulate other bus use, but sets the standard which other bus services need to achieve in order to attract passengers.”

development style similar to many south-western US cities. The urban form category that appears to best fit this region is the dispersed. There are a range of 25 Park and Ride facilities in this area planned and arranged around 6 freeway corridors. This appears to be similar to the Type 3 (Corridor) category (see Table 3.3).

There are no discovered expressed priorities of the key outcomes (level one land-use objectives) for the Houston area. However, from the urban form and general US legislative environment, it is postulated for this project that Environmental Sustainability and Energy Efficiency would be allocated relatively low priority and that Economic Development, Safety and Public Health & Security would be allocated the main priorities.

The number of parking spaces in each corridor varies between 3,000 and 7,500. There has been a major expansion in Park and Ride facilities since 1980, growing from about 6,500 to around 28,500 spaces in 1998. Occupancy and usage varies considerably with some lots experiencing 100% utilisation, and corridor utilisation varying between 34% and 61% (averaging 48%) or between 1,130 and 3,643 vehicles (total 13,781) in 1998. The well used lots are those with high frequency bus services and direct access to the freeway HOV lanes. Surveys indicate that 38-46% of Park-and-Ride bus passengers have transferred from the drive-alone mode.

4.2.6 Portland

This assessment will consider the Tri-Met Route 96 Park and Ride system, operating from Wilsonville, through Tualatin to the central city (TCRP, 2004). The urban form for this area is linear – villages/nodal, as Portland is based in an area with a series of river valleys with outlying townships.

This bus-based Park and Ride system can be considered a Type 2 (Link and Ride) system (see Table 3.3), with a series of 4 small parking stations along its route. The largest station, and closest to the city centre, contains 204 parking spaces at Tualatin. It is located just prior to entering the I-5 freeway for a 20 minute non-stop trip into the city centre, running in mixed traffic.

There are no discovered expressed priorities of the key outcomes (level one land-use objectives) for Portland. However, based on the observed urban form, general US legislative environment and the historical direction of Oregon planning legislation (focussing on Smart-growth ideology), it is postulated for this project that Environmental Sustainability, Energy Efficiency and Accessibility could receive the primary emphasis.

The limited data available on this system indicated that the demand for the system is high with the Tualatin parking station reaching capacity shortly after opening. Morning peak demand (0620-0800 hrs) on the Route 96 service is about 350 passengers (all boarding types, not just Park and Ride). Over 95% of passengers were commuting to work or education sites.

4.3 Checking Cities against the Framework

In this section each of the 6 examples presented in the previous section will be compared against the Assessment Framework Matrix (as shown in Table 3.8) in terms of the actual system operating and the proposed priority of objectives for that urban area.

4.3.1 Auckland

The information in the previous section may be summarised as Auckland (North Shore Busway) is UF 1/PR 3, with primary emphasis on Economic Development and Safety and secondary emphasis on Accessibility and Environmental Sustainability.

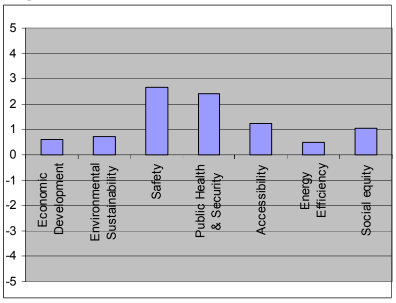
In terms of the weighted summary score (WSS), the Type 3 (Corridors) Park and Ride category (WSS = 1.253) is nominally second best to the Type 2 (Link & Ride) (WSS = 1.485). However, as noted earlier, Auckland region has initiated investigations into whether the system could benefit from conversion to a system consistent with the

Type 2 (Link and Ride) by possibly extending the system with parking stations further north, including possibly at Orewa.

In terms of the profile (see Figure 4.1), the Economic Development indicator is positive and close to the best of the options. The Safety indicator is very positive and second to the Type PR 2 (Link & Ride), principally as there is still more car driving involved to access the system from beyond the urban boundary. Accessibility again is strongly positive and second to the Type PR 2, for similar reasons to Safety, and the Environmental Sustainability indicator is positive and as good as any other option.

Overall, for Auckland this indicates that if a Park and Ride system was being established that the system currently being developed is likely to be a good choice in terms of meeting objectives collectively and individually.

Figure 4.1 UF 1/PR 3 Profile for Auckland



4.3.2 Wellington

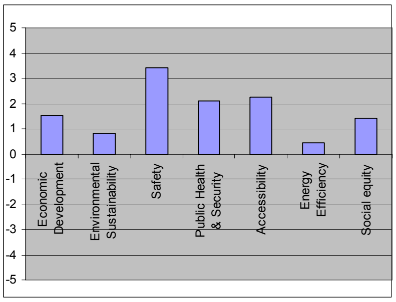
The information in the previous section may be summarised as Wellington is UF 2/PR 2, with primary emphasis on Economic Development and Accessibility and secondary emphasis on Safety and Environmental Sustainability.

In terms of the WSS, the Type 2 (Link & Ride) category is nominally the best option by some margin in the Assessment Framework Matrix, with a score of 1.699 and the next best being 1.195 for the Type 3 (Corridors).

In terms of the profile (see Figure 4.2), all the indicators are higher than any other Park and Ride type for this urban form. The Economic Development indicator is solidly positive (at about 1.5) and the Accessibility indicator is scores well at just over 2. Safety is the highest indicator with a score of over 3, but the Environmental Sustainability indicator is just under 1.

Overall, for Wellington this indicates that the current Park and Ride system operating in association with the rail-based public transport system is likely to be the best option in terms of meeting objectives collectively and individually.

Figure 4.2 UF 2/PR 2 Profile for Wellington



4.3.3 Shrewsbury

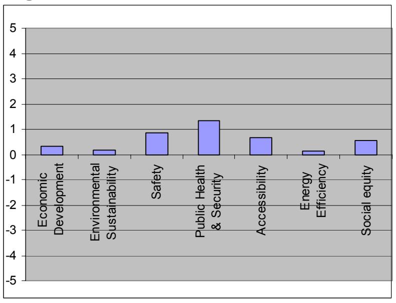
The information in the previous section may be summarised as Shrewsbury is UF5/PR1, with primary emphasis on Accessibility, Safety and Environmental Sustainability, and secondary emphasis on Economic Development and Personal Health & Security.

In terms of the WSS, the Type 1 (Necklace) category (WSS = 0.824) is nominally the 3rd option behind the Type 2 (Link & Ride) (WSS = 1.405) and Type 6 (Nodal) (WSS = 1.125) categories, and is just ahead of the Type 3 (Corridors) score.

In terms of the profile (see Figure 4.3), the Accessibility indicator is positive at approximately 0.7 and no option exceeds this by a large margin (Type PR 2 has the best score at about 1.1). The Safety indicator scores just under 1 and again is not exceeded significantly by any other categories (Type PR 2 has the best score at about 1.7). Whilst the Environmental Sustainability indicator may be second best score amongst the categories, having a score of less than 0.25 does not indicate a strong level of achievement of that objective, which is poor across all categories for this urban form. The Economic Development indicator is similar, in that it is positive for this situation but less than 0.5 and no PR category scores well in it. For Personal Health and Security, the score is stronger at about 1.3 and is the third best amongst the categories (although some even score negatively for this indicator).

Overall, for Shrewsbury this indicates that the choice of the Type 1 (Necklace) system could be considered as workable but there are better options (such as Type UF 2 (Link & Ride) or Type UF 6 (Nodal)). This view would reinforce the views of many critics of the typical UK Park and Ride system, who do not appear to be opposed to Park and Ride as a concept, rather there are some specific aspects of it which cause concerns and they believe could be improved (CPRE, 1998).

Figure 4.3 UF 5/PR 1 Profile for Shrewsbury and Oxford



4.3.4 Oxford

The information in the previous section may be summarised as Oxford is very similar to Shrewsbury and is UF5/PR1, with primary emphasis on Accessibility, Safety and Environmental Sustainability, and secondary emphasis on Economic Development and Personal Health & Security.

In terms of the WSS and the profile (see Figure 4.3), the same commentary and summary can be made as for Shrewsbury. However, this does not address the fact that Oxford is achieving its desired outcomes better than Shrewsbury. For example, Shrewsbury's usage is mainly by older shoppers, which would not address access to the town centre during peak periods when network capacity is under pressure with its attendant effects, whereas almost all Oxford's users are workers and students commuting. The difference between the two towns is that Oxford has an implemented integrated transport strategy, whereas Shrewsbury is still working towards a more integrated, sustainable transport system. This demonstrates that the three key variables[6] for categorising Park and Ride systems must be borne in mind when seeking to identify a Park and Ride system for an urban area. Different combinations of those variables from those assumed in this research project could potentially cause a different set of results in the matrix from which decisions are being based.

4.3.5 Houston

The information in the previous section may be summarised as the Houston area is UF7/PR3, with primary emphasis on Economic Development, Safety and Public Health & Security, and secondary emphasis on Accessibility and Social Equity.

In terms of the WSS, the Type 3 (Corridors) category is nominally the 4th best option although all the weighted summary scores are negative. Nevertheless, none of the weighted summary score are strongly negative with the largest just over -0.5, and the Type 3 (Corridors) category are -0.223.

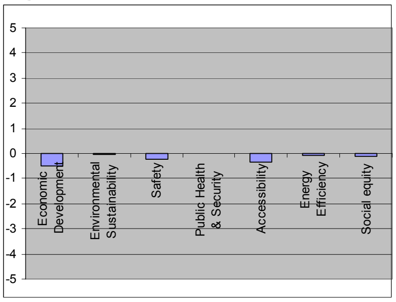
In terms of the profile (see Figure 4.4), all the indicators are negative, but all have small values. The Economic Development indicator is in a group of second best categories at about -0.5 and is the largest absolute value in the profile. Only the Type 4 (Dispersed) category scores better for Economic Development in UF 7. A negative value indicates that introducing the Park and Ride scheme would likely add more costs overall than benefits to the economy of the urban area in which it operates. The Safety indicator is slightly negative for all categories, based on a range of small deteriorations caused by the Park and Ride system being introduced (such as slightly more car travel in suburban areas). However the deterioration is not significant of itself, but it could be seen as a lost opportunity given the safety benefits noted elsewhere in the matrix. The Public Health and Safety indicator score is zero, indicating in this assessment neither benefit nor deterioration from the introduction of

[6] 1. Parking Station locations, 2. integration with wider public transport systems, and 3. forming part of a complementary, comprehensive transport strategy.

a Park and Ride system to this urban area. This indicator was very close to zero for all Park and Ride categories with this urban form. The Accessibility indicator score is also negative and close to zero (about -0.3), but is the second best score of all categories for this indicator. For the Social Equity indicator, all categories are very close lying between zero and -0.1, so there is little to choose between.

Overall, for the Houston area this indicates that there is little to choose between the various categories for this urban form, and the Type 3 (Corridors) category lies in the middle of the choices. Achieving a favourable assessment of the Park and Ride system categories in this urban area may lie as much in the choice of urban form category. If, for example, the Urban Form category 4 (Radial – Corridors) or Urban Form category 5 (Radial – Homogeneous) had been chosen, then the resultant assessments would have indicated positive outcomes and that the choice of Type 3 (Corridors) Park and Ride category was still a sound option despite not the best indicated. A further consideration is that if the decision-makers have any thresholds for objectives to achieve, such as to improve the economic development of the urban area, a negative score for an indicator may be seen as a fatal aspect of an option and remove it from further consideration.

Figure 4.4 UF 7/PR 3 Profile for Houston



4.3.6 Portland

The information in the previous section may be summarised as Portland (Wilsonville – Portland) is UF 2/PR 2, with primary emphasis on Environmental Sustainability Energy Efficiency and Accessibility. This is similar to Wellington, but with a different suite of priorities for the outcomes.

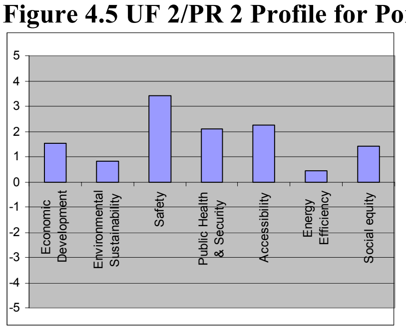
In terms of the WSS, the Type PR 2 (Link & Ride) category is nominally the best option by some margin in the Assessment Framework Matrix, with a score of 1.699 and the next best being 1.195 for the Type PR 3 (Corridors).

In terms of the profile (see Figure 4.5), the Environmental Sustainability is just less than one, not indicating strong achievement of the outcome but it is the best for this indicator amongst the Park and Ride categories. Whilst it is not the highest scoring indicator for this Park and Ride profile, the fact that Portland/Oregon place significant weight on environmental planning matters may result in it being the indicator given the most scrutiny.

The Energy Efficiency indicator again scores highest of all categories for this urban form but they are all low, being between zero and 0.5. In contrast, the Accessibility indicator is scores well at just over 2 and is considerably better than the other Park and Ride categories under this urban form category.

Overall, for Portland this indicates that this Park and Ride category would operate well and achieve the urban form objectives well overall. However, it may perform well in objective areas that are less important to decision-makers and the community, and only modestly in areas which are important as indicated in the results for the Environmental Sustainability and Energy Efficiency indicators. As noted for the Houston area example above, if thresholds are applied in decision-making then the decisions and outcomes could be more complex.

Figure 4.5 UF 2/PR 2 Profile for Portland



4.4 Main Findings of the testing against real cities

Six cities (two from New Zealand, two from the UK and two from the USA) have been checked against the Assessment Framework Matrix, using available data and local knowledge, as well as noted selected assumptions where needed. These provided a range of different urban form/Park and Ride combinations, as well as some common ones with other local differences to be considered.

The purpose of the testing is to establish whether the information provided in the initial matrix is robust and reliable enough to be able to place confidence in the matrix for decision-making. (It was not intended to assess every combination of urban form categories and Park and Ride categories.)

The findings of this testing are summarised in Table 4.1 and the following commentary.

Table 4.1 Summary of testing against real cities

City	Nominal categorisation	Primary outcome areas	Secondary outcome areas	Evaluation of PR type	Comment
Auckland	UF 1/PR 3	Economic Development, Safety	Accessibility, Environmental Sustainability	2nd to PR 2	Good choice on which to develop the BRT system
Wellington	UF 2/PR 2	Economic Development, Accessibility	Safety, Environmental Sustainability	Best option	Good choice for this rail based system
Shrewsbury	UF 5/PR 1	Accessibility, Safety, Environmental Sustainability	Economic Development, Public Health & Security	3rd best overall behind PR 2 and PR 6	Workable option but better exist
Oxford	UF 5/PR 1	Accessibility, Safety, Environmental Sustainability	Economic Development, Public Health & Security	3rd best overall behind PR 2 and PR 6	Operating better than Shrewsbury as has integrated transport policy implemented
Houston	UF 7/PR 3	Economic Development, Safety, Public Health & Security	Accessibility, Social Equity	All options very similar, PR 3 in middle of options	Choice of urban form is important & different UF may indicate different choices
Portland	UF 2/PR 2	Environmental Sustainability, Energy Efficiency, Accessibility	Not indicated	PR 2 is best option overall	Is not best for achieving priority outcomes, good in “unimportant” areas

- In most examples, the choice of Park and Ride system that is operating was identified as sound, if not always the optimal in terms of the initial matrix as it stands.
- In Auckland's case, the current investigations of modifying and extending the Busway Park and Ride system was shown as a sensible potential improvement from the matrix outputs.
- The comparison of Shrewsbury and Oxford reinforced the need to consider more than just the information in the matrix for considering how a Park and Ride system may assist in achieving urban form objectives. The other key aspects of public transport integration and a supportive transport framework are also important and could influence the final outcomes.
- The Houston area example demonstrated that the choice of urban form category could be important to decisions and perceived achievement of objectives.
- The two USA examples highlighted the potential effect of required thresholds for achievement of objectives in the decision-making process.
- It may be concluded from this testing that the initial matrix has provided sound insights and information in relation to the six cities tested, and that the city information has demonstrated that the initial matrix provides useful analysis of UF / PR interactions.

Chapter 5 Application of Assessment Framework as a Predictive Tool

The purpose of this chapter is to trial the Assessment Framework as a predictive tool to assist hypothetical decisions related to choosing a Park and Ride system for a range of theoretical urban areas. This trial is intended to further develop the testing of the previous chapter and assess whether the Assessment Framework Matrix can be applied satisfactorily, produces reliable and sensible results and is not biased to or away from particular solutions.

Initially generic urban area data will be proposed, followed by the application of this data to the Assessment Framework Matrix. These example urban areas do not represent specific real cities, but are intended to present a cross-section of potential urban form situations which may be encountered. This diversity should allow a range of perspectives to be developed on the application of the Assessment Framework Matrix as a planning or predictive tool. The issues and considerations surrounding the provision of advice on the outputs of the process for decision-making are discussed, along with final observations on the potential transfer of this process to real situations.

5.1 Identification of generic urban forms data

The following are descriptions of five generic urban forms (Model A to Model E) to be used in assessing the Assessment Framework Matrix as a predictive tool:

Model A: A city centred on a strong core with 5 strong fingers of urban development radiating away from the core. The core is set very close to a major seaport. There are no significant villages or other settlements in the adjacent rural areas. The community places significant emphasis on achieving Social Equity and Energy Efficiency objectives.

Model B: A city with a declining central core, and with significant commercial and industrial development occurring at its periphery in its urban expansion areas. The intervening areas are largely homogeneous residential and light commercial activity. A range of townships exist within easy commuting distance of the city for employment, social and other activities. The city wishes to revitalise its central city. The community places significant emphasis on achieving Economic Development (especially of the core) and Safety objectives.

Model C: A multi-centred city set in a series of river valleys with sharply rising hills between the developed urban areas in the valleys. A range of townships exist within easy commuting distance of the city for employment, social and other activities. The community places significant emphasis on achieving Environmental Sustainability and Economic Development objectives.

Model D: A modest-sized traditional "new world" Western city located on rolling countryside with a sound core which has no significant competition from other centres in the city. A small number of townships exist in the surrounding rural areas, which are largely dependent upon the city and operate predominantly as dormitory settlements for the city. The community places significant emphasis on achieving Accessibility and Environmental Sustainability objectives.

Model E: A multi-centred mega city, sprawling across a large plains area. There can be large distances between activities in the city (such as between residential and employment areas). There are, in many areas, relatively high densities of activities, including medium density residential areas, and strong activity corridors for business and commercial development. No significant townships in the surrounding rural areas affect the dynamics of the city. The community places significant emphasis on achieving Public Health & Security and Social Equity objectives.

5.2 Application as predictive tool with generic urban forms

In this section, each of the generic urban forms (Models A-E) outlined in the previous section will successively be applied to the Assessment Framework Matrix (see Table

3.8) in order to explore what information could be provided to decision-makers about Park and Ride systems that may be applicable in that context.

It is assumed in these assessments that the Park and Ride systems would be applied in optimal conditions (i.e. the system issues related to the two non-geographical key Park and Ride classification variables are all aligned and supportive).

The following table presents the Weighted Summary Scores taken from Table 3.8, for quick reference in the following discussion.[7]

Table 5.1 Quick Reference WSS from Assessment Framework Matrix

	PR 1	**PR 2**	**PR 3**	**PR 4**	**PR 5**	**PR 6**
UF 1	0.883	1.485	1.252	0.108	-0.023	0.935
UF 2	0.923	1.699	1.195	0.298	-0.048	1.035
UF 3	0.817	2.125	1.195	0.392	0.094	1.091
UF 4	1.006	1.692	1.532	0.080	-0.209	1.093
UF 5	0.824	1.405	0.800	-0.217	-0.171	1.125
UF 6	0.316	0.852	0.983	0.068	-0.310	0.065
UF 7	-0.370	-0.142	-0.223	-0.003	-0.562	-0.200

5.2.1 Model A

The urban form for this option is best described by Urban Form Type UF 4 (Radial/Concentric – Corridors). The strong fingers of urban development create the corridors, which may have no or low key urban development between them, and sufficient gradation of urban activity to support a corridors perspective rather than a homogeneous classification.

In referencing the Assessment Framework Matrix (see Chapter 3, Table 3.8), it is quickly apparent that Park and Ride Types PR 2 (Link & Ride) and PR 3 (Corridors) are the best performers on the basis of the weighted summary score. In terms of the priority profile indicators (Social Equity and Energy Efficiency), there is little difference between the scores of the Type PR 2 and PR 3 categories, which are the

[7] This table shows the Weighted Summary Scores based on an example scoring exercise, and should not be relied upon for application to real world situations without review and confirmation.

highest for these indicators for this urban form and are also all positive, albeit less than one.

Given the nature of the Model A's urban form in relation to the two best performing Park and Ride categories, a recommendation could be made in support of adopting Park and Ride Type PR 3 (Corridors). The main disadvantage of Type PR 2 (Link & Ride) in this situation is that it establishes parking stations in the surrounding villages and rural areas, which do not need serving in this scenario and would be an inefficient component.

5.2.2 Model B

The urban form for this option is best described by a mixture of Urban Form Types UF 6 (Radial/Concentric – Peripheral) and UF 2 (Linear – Villages). The main urban area presents clear features of the "edge city" form highlighted in Type UF 6, but the surrounding villages influencing the function of the city present a form similar to Type UF 2, especially with the desire of the community to restore its core.

When applying this to the Assessment Framework Matrix (see Chapter 3, Table 3.8), the better performing Park and Ride categories for each urban form category should be identified. With Type UF 2, the Park and Ride category PR 2 (Link & Ride) is a clear leader but Types PR 1 (Necklace), PR 3 (Corridors), and PR 6 (Nodal) all provide good alternative solutions at about equal overall performance. In terms of Type UF 6, the Park and Ride categories PR 2 and PR 3 are clearly the better options. Therefore Types PR 4 (Dispersed) and PR 5 (Collar) should be dismissed at the first pass.

As the described urban form also does not have any clear nodes within the urban area other than the central city (and a generous definition of the peripheral ring may include that), it is valid to also dismiss Type PR 6 (Nodal). Taking a similar pragmatic view of the urban form in relation to where the Park and Ride categories would locate the parking stations raises the issue for Type PR 1 (Necklace) locating the parking stations in the high activity area at the periphery of the city, which could have relatively high land values. In addition, the periphery would be one of the two key destination areas (the other being the core) in which Park and Ride systems usually are attempting to reduce traffic, not attract even more cars to then transfer to public transport. Therefore Park and Ride Type PR 1 should also be dismissed.

This leaves Types PR 2 (Link & Ride) and PR 3 (Corridors) to compare, and each of the two different urban form categories used to describe this city could favour a different solution. Nevertheless, for urban form category UF 6, there is relatively little difference between the two Park and Ride categories despite indicating that Type PR 3 (Corridors) would perhaps achieve the profile outcomes for Economic Development (especially of the core) and Safety slightly better. However, when considering the two options in light of the urban form category UF 2, there is a considerable preference for Park and Ride category PR 2. In addition, the Type PR 2 Park and Ride system would better support the central city, by enabling and encouraging more rural sourced trips to pass through the peripheral activity zone and onto the core area.

So, given the nature of the Model B's urban form in relation to the best performing Park and Ride categories, a recommendation could be made that either Park and Ride categories PR 2 (Link & Ride) or PR 3 (Corridors) could work well, with Type PR 2 being a better overall option, especially if the decision to be made is looking to strongly support the revitalisation of the central core.

5.2.3 Model C

The urban form for this option is best described by Urban Form Type 2 (Linear – Villages/Nodal). In addition to the presence of nearby towns, the strong linear form of the river valleys and steep hills that make interaction "across" the city difficult dismisses the other possible choice of UF 4 (Radial/Concentric – Corridors).

On consideration of the Assessment Framework Matrix (see Chapter 3, Table 3.8), the better performing Park and Ride categories (particularly in terms of the weighted summary scores) are Type PR 2 (Link & Ride) as a clear leader with Types PR 1

(Necklace), PR 3 (Corridors), and PR 6 (Nodal) all providing good alternative solutions at about equal overall performance.

The two priority outcome indicators (Environmental Sustainability and Economic Development) for these options do not show significant differences, and all are between 0.5 and 1.5, so benefits would accrue through the introduction of any of the Park and Ride categories noted. Therefore consideration is needed of the practical implications of the geography of the 4 categories identified. The exact nature of the distribution of the centres within the corridors in the urban area and the quantum of demand related to the surrounding townships would be key determinants. In this situation, the recommendation of the preferred Park and Ride system category could potentially be represented in Table 5.2.

Table 5.2 Model C Park and Ride Preferred Options

	Strong township demand	**Weak township demand**
Many urban nodes	PR 2 (Link & Ride)	PR 6 (Nodal)
Few urban nodes	PR 1 (Necklace)	PR 3 (Corridors)

So, given the nature of Model C's urban form in relation to the best performing Park and Ride categories, a recommendation could be made that any of four Park and Ride categories (PR 1, PR 2, PR 3 or PR 6) could work well, with some stronger support for whichever category was applicable from the urban form sub-options in Table 5.2.

5.2.4 Model D

The urban form for this option is best described by Urban Form Type UF 5 (Radial/Concentric – Homogeneous), with elements of Urban Form Type UF 2 (Linear – Villages/Nodal).

The Assessment Framework Matrix (see Chapter 3, Table 3.8) indicates that the better performing Park and Ride categories (particularly in terms of the weighted summary scores) for urban form category UF 5 (Radial/Concentric – Homogeneous) are Type PR 2 (Link & Ride) with PR 6 (Nodal) clearly a second sound option. Types PR 1 (Necklace) and PR 3 (Corridors) have similar results and whilst possible options are clearly third best in terms of performance against the objectives. If consideration is also given to the influence of the Urban Form category UF 2 (Linear – Villages/Nodal), then reasonable Park and Ride category options in order of performance are PR 2, PR 3, PR 6 and PR 1. Thus the initial choice would appear to be between Park and Ride categories PR 2 and PR 6.

With regard to the priority outcome indicators for this city (Accessibility and Environmental Sustainability), there is almost no difference between Types PR 2 (Link & Ride) and PR 6 (Nodal) under Urban Form category UF 5. So the recommendations under this scenario should note the similarities and identify any other relevant issues, such as the relative costs of the options in relation to the levels of demand in the catchments or the benefits and impacts of establishing a Park and Ride node in the city's suburban fabric.

5.2.5 Model E

The urban form for this option is best described by a mix of Urban Form Types UF 3 (Radial/Concentric – Nodal) and UF 4 (Radial/Concentric – Corridors).

On consideration of the Assessment Framework Matrix (see Chapter 3, Table 3.8), the better performing Park and Ride categories (particularly in terms of the weighted summary scores) for these urban form categories are in order Types PR 2 (Link & Ride), PR 3 (Corridors), PR 6 (Nodal) and PR 1 (Necklace), with PR 2 the best overall performer by a significant margin and PR 3 scoring well as a second option.

However, considering the practical implications of the geography of these four Park and Ride categories in relation to the urban form could influence which to take further in the assessment. The Type PR 1 (Necklace) is not likely to be especially effective as having the parking stations only at the edge of a very large city would not be efficient in optimising their locations in terms of their catchments. Similarly the Type PR 2 (Link & Ride) category includes parking stations in villages and rural areas surrounding an urban area, but in this situation there is little demand in these areas and the provision of such parking stations would be poor use of resources. This is particularly pertinent as the rural/village provision is the key difference between Types PR 2 and PR 3. From these considerations, the choice then appears to be between Types PR 3 (Corridors) and PR 6 (Nodal).

Reviewing the performance of the priority outcome indicators for this city (Public Health & Security and Social Equity) shows that the scores for both Park and Ride categories are positive and similar, with Type PR 3 (Corridors) having marginally but consistently better results. Therefore a recommendation could be made that either Park and Ride categories PR 3 (Corridors) or PR 6 (Nodal) could work well, with Type PR 3 being a better overall option and the choice could be determined by considering other (secondary priority) profile indicators such as Accessibility or Economic Development (for which the choice would clearly by Type PR 3) or using other criteria, such as site availabilities or staging issues.

5.3 Assessment of results and improvements

A number of observations may be made from the process outlined in the previous section. These are presented in the following paragraphs in no particular order of importance along with a tabulated summary of the results (see Table 5.3):

Table 5.3 Summary of results from trial application on generic urban forms

City	Nominal Urban Form categorisation	Primary outcome areas	Recommended PR type	Comment
Model A	UF 4	Social Equity, Energy Efficiency	PR 3 (Corridors)	PR 2 (Link & Ride) not chosen as less efficient for provision of infrastructure
Model B	UF 6 and UF 2	Economic Development, Safety	PR 2 (Link & Ride)	Little to choose between PR 2 and PR 3
Model C	UF 2	Economic Development, Environmental Sustainability	Any of PR 1, PR 2, PR 3 or PR 6	Choice would depend upon detail of number of urban nodes and strength of satellite towns
Model D	UF 5 mainly, with elements of UF 2	Accessibility, Environmental Sustainability	PR 2 (Link & Ride) or PR 6 (Nodal)	Very similar results for either category, and choice could be made through other determinants
Model E	UF 3 and UF 4	Social Equity, Public Health & Security	PR 3 (Corridors)	PR 6 (Nodal) also works well, but not as good over key indicators

- With the way that the Assessment Framework Matrix was applied, it did not point to the same Park and Ride category irrespective of the urban form category being considered.

- The Weighted Summary Scores proved to be a reliable first “sieve” to identify the best few Park and Ride categories which should be considered further with more detailed assessment. There is an observable correlation between the magnitude of the Weighted Summary Score and the amplitude of the indicator profile in each cell of the matrix. If this correlation ceases to exist (perhaps through a re-working of the matrix inputs), then using the Weighted Summary Scores as the first sieve would not be viable.

- The situations where a particular town or city presented characteristics of more than one urban form category required careful assessment. Consideration of the relative strength of the different characteristics was needed; a form of weighting could be used in reviewing the information from the different urban form categories.

- In assessing the urban form category, thought also needs to be given to what is the future desired urban form as much as what is the current urban form from which contemporary dynamics would evolve.

- The analysis undertaken in this chapter has highlighted the need to review the scores in the spreadsheets contributing to the Assessment Framework Matrix. An obvious example area being the results shown for the Urban Form Type UF 3 (Radial/Concentric – Nodal) / Park and Ride Type PR 2 (Link & Ride) combination, which are considerably higher than any other combination. Conversely, the lack of variation amongst many other parts of the matrix also raises questions as to whether the original inputs were too subtle in their scoring and use of a greater range of scores (appropriately) may provide clearer differences between the options.

5.4 Discussion of predictive capability and use

The use of the Assessment Framework Matrix as proposed in this project can be considered to be reasonably straightforward, as indicated from the material in this and the previous chapters.

The reviews and investigations in this and the previous chapter have shown that use of the Assessment Framework Matrix produces intuitive and sensible results. Subject to refinement or review of the inputs (especially the assessment scores for the achievement against level three objectives) to the spreadsheets contributing to the Assessment Framework Matrix, it should be able to be used with a degree of confidence to inform investigations of the most appropriate types of Park and Ride systems for particular urban areas.

Creating the Assessment Framework Matrix from initial basic data is much more complex and time consuming, requiring the creation or review of 42 spreadsheets (for the combinations of Park and Ride and Urban Form categories used in this project). This makes the use of the methodology from first principles much less attractive to most users.

Some examples presented in this chapter required consideration of “practical” context-specific issues in the choice of preferred Park and Ride category. This resulted in some Park and Ride categories being dismissed which would not have been dismissed simply using the Assessment Framework Matrix. This raises three questions in relation to the matrix: is there a missing dimension which could be introduced to the matrix; should some combinations of urban form / Park and Ride categories simply be abandoned; and is this a justifiable extra step in the analysis methodology?

In response to these questions, there is no obvious way in which this “practicality” factor could be introduced into the matrix as there are too many variables and possible scenarios. All potential combinations of urban form and Park and Ride categories should be assessed and presented for completeness and transparency in the process. It appears that the appropriate response is to acknowledge this as a valuable additional step in the methodology, both to speed the focussing to viable options and to save potentially redundant assessment effort in the later more detailed analysis of potentially non-viable or difficult categories.

In cases where the difference between two or more options is small, especially in relation to priority outcome areas, the use of secondary priority profile indicators could provide additional information in helping to determine a decision. Alternatively, where the difference between two or more options is small, especially in relation to priority outcome areas, more than one potential solution can be presented from this assessment process (with appropriate supporting information and discussion) and a final choice by the decision-makers should be invited using any other factors or determinants available and useful to them.

This latter point recognises that different groups and decision-makers do have different decision-making processes in addition to the technical one (which provides input from analyses such as this). Those processes may focus on minimising risk, producing "no-regrets" decisions, managing cash flows, ensuring equity across a community or providing emphasis to certain sectors. Notwithstanding any of these occurring implicitly or explicitly, it is imperative that the processes used to provide the technical information and recommendations is objective, transparent and repeatable.

Matters considered in the chapters 3 and 4 have raised a question about whether a single predictive matrix is sufficient or whether there is a need to create a new one for each situation or urban area. This is best considered in the light of who is using the matrix. There is a strong case to be made for the creation (and periodic review) of a "master" or standard matrix, which can be used by practitioners and professionals when conducting technical reviews and analysis. This would contain a series of standardised scores for the level three objectives achievement, along with objective weightings for the various urban forms derived (averaged) from inputs of a wide range of stakeholders and decision-makers from all types of urban forms over time. Similarly there is a strong case that a new matrix should be created for each urban area or each investigation, in which the stakeholders, affected communities and local decision-makers contribute to the derivation of the weightings of the objectives (and to scores of subjectively assessed level three objective achievements). In such circumstances, the new matrix would only involve modifying the weightings for the urban form categories relevant to that location (perhaps one or two sets of weightings would be affected).

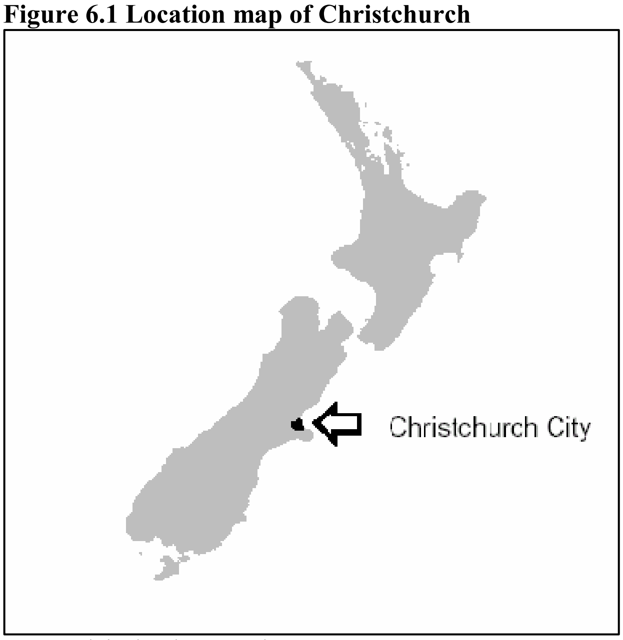
Chapter 6 Case Study – Christchurch, New Zealand

In this Chapter a case study is undertaken using Christchurch, New Zealand as a potential real world example of where, if Park and Ride is pursued, a decision is required as to the most appropriate type of Park and Ride system category for introduction. At least in part, this is motivated by both Christchurch City Council and Environment Canterbury having passed resolutions supporting Park and Ride for Christchurch and wishing to see options investigated. This chapter presents background data on Christchurch and on the Greater Christchurch Urban Development Strategy for use in the subsequent application of the Assessment Framework Matrix to Christchurch.

6.1 Christchurch Background Data

Christchurch is located near the middle of the east coast of the South Island of New Zealand, as indicated in Figure 6.1 below. It has a population of approximately 340,000 in 2006, along with more than 50,000 in its commuting catchment in surrounding districts.

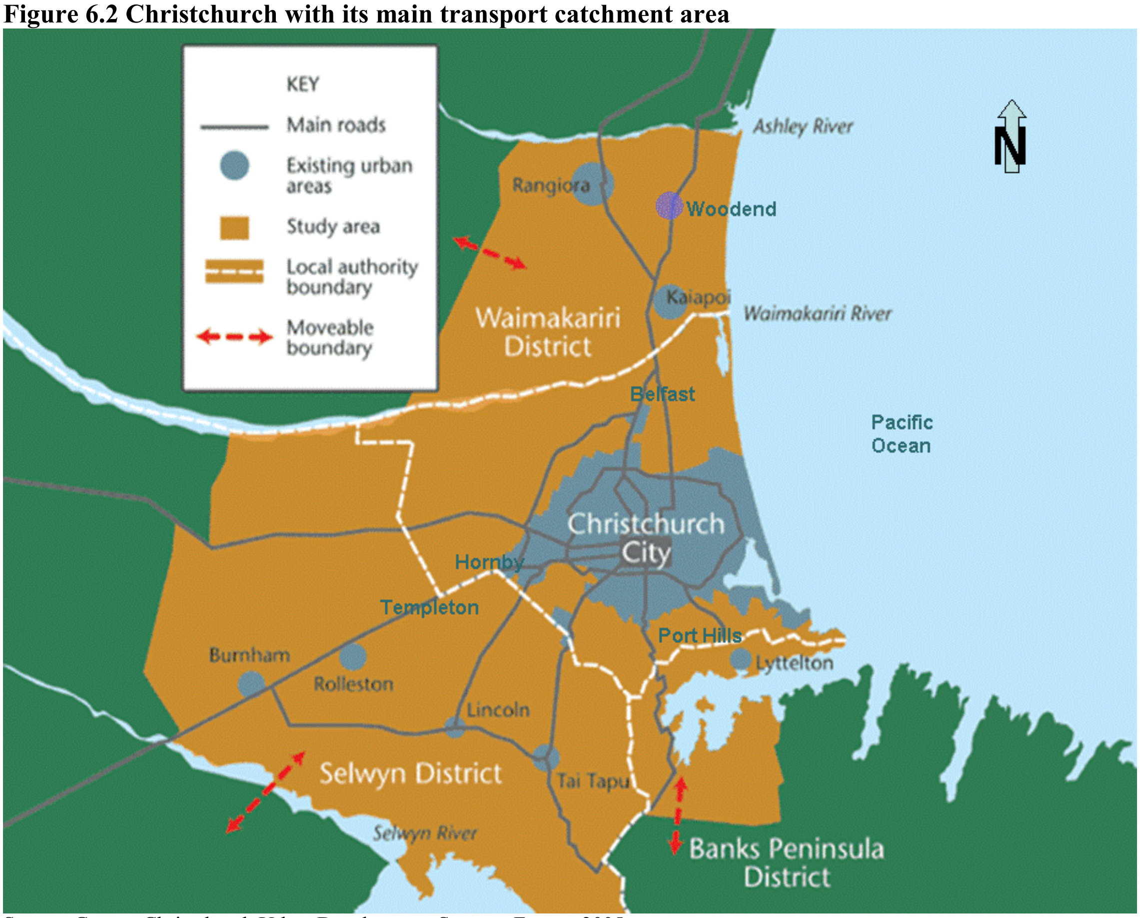
Figure 6.1 Location map of Christchurch



Source: Christchurch Fact Pack, www.ccc.govt.nz

Christchurch (see Figure 6.2) is predominantly developed on flat terrain, with some residential development on the Port Hills on its southern edge. It is contained to the south by the Port Hills and to the east by the Pacific Ocean. It is the principal city in the South Island, and services a significant rural hinterland and economy as well as creating and supporting its own economic activity.

Figure 6.2 Christchurch with its main transport catchment area



Source: Greater Christchurch Urban Development Strategy Forum, 2005

It has historically tended to develop in a generally radial concentric fashion (tending to initially expand along key corridors and filling in between the corridors subsequently). Now that it is constrained to the east and south, future urban expansion in the current city is likely to be to the north (Belfast) and the south west (Wigram, Templeton and Hornby). Presently Christchurch's shape is becoming more rectangular or a slightly flattened ball, with dimensions east-west of approximately 20 km and north-south of approximately 15 km.

There are a number of outlying townships surrounding Christchurch, which largely rely upon Christchurch for employment, cultural and business activities. These include Kaiapoi, Woodend, Rolleston, Burnham, Lincoln, Tai Tapu and Lyttelton. Rangiora, which is also an outlying township and has a population in excess of 15,000, is becoming increasingly less dependent upon Christchurch as it grows to a more self-sustaining size.

Christchurch does not have a strong network of arterials, although there are some strong transport demand corridors. Most arterial roads are two lane roads (one lane in each direction), with a number of more important arterials having four lanes. However, almost all arterials have very poor access control and very frequent intersections, which together badly compromise the capacity and safety of these roads. The key transport infrastructure corridors, whilst having strong travel demands on them, are poorly developed with regard to all modes.

Traffic volumes in Christchurch are growing at approximately 2-3% per year, although some corridors serving current growth areas are experiencing considerably in excess of that. Historically travel has experienced a high level of service, but with ongoing growth and few improvements in the transport system capacity, the level of service for any mode is beginning to deteriorate at an accelerating rate, with some roads experiencing mild congestion for several hours each day (such as Riccarton Road and Papanui Road).

There is a very high car ownership rate in New Zealand generally, including Christchurch. For Christchurch it is considerably over 600 vehicles/1000 population. Christchurch has over 36,000 parking spaces in its central city area. The city council manages the operation of about 10,500 of these spaces (including on-street spaces).

Christchurch has an extensive bus-based public transport system (with one ferry-based service), focussed principally in the urban area. The system is predominantly based on radial bus routes, with one orbital service and one cross-city service. The urban services are grouped into service quality types, with a range of “core” corridors providing high frequency, direct services on key demand corridors. There are lower quality services servicing Rangiora and Kaiapoi to the north, Lyttelton to the south and Lincoln to the southwest. A low frequency service exists for Rolleston. The public transport system currently carries in excess of 16M passengers per year (which equates to about 3% of personal (non-walk) trips.

Within the Christchurch urban area, there are also a range of suburban centres, of varying size and function (see Figure 6.3).

> *"Many of the larger suburban centres serve as focal points for co-location of community services and facilities and for social interaction; several also serve as consolidation focal points for population intensification, and reinforce the transport efficiencies which flow from such an urban land use pattern. Some of these centres have developed historically, and others more recently by way of a planned hierarchy which distributes centres of similar size and function throughout the urban area to ensure that all areas are well served with a range of centres which meet most local requirements."* (Christchurch City District Plan, 2006)

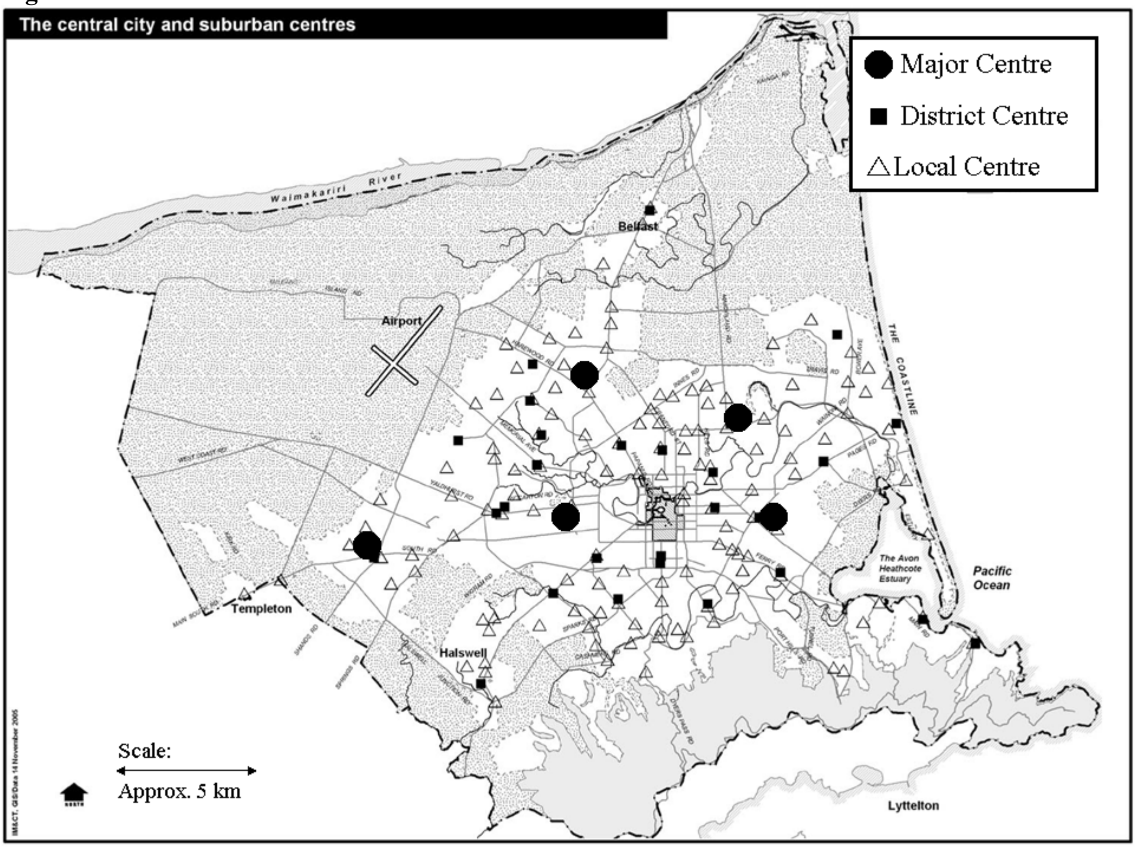
The larger centres (noted as "major" and "district" in Figure 6.3) are located to maximise accessibility, especially by public transport, cycle and foot. Christchurch has the unusual and challenging situation of having most of its major suburban centres within 5-6 km of its central city. These centres are key activity areas for the city, being significant commercial and employment areas as well as having enabling zoning for higher density residential development in surrounding areas. The Christchurch City District Plan (2006) notes that

> *"they contribute significantly to the urban form and amenity of an area. Importantly, district centres serve as focal points in terms of providing important public and private services and facilities to the community.*
>
> *The majority of district centres are comprised of a core business area with a 'fringe' of adjacent retail, office and community activities (including health facilities, educational activities, and facilities such as libraries and pools)."*

In terms of Figure 6.3, Major Centres are considered to have over 25,000 m^2 of commercial floor space, where as District Centres are usually over 5000m^2 total floor space. Both types would usually also include a number of the following elements:

- One or more supermarkets;
- Shopping mall with a department store, supermarket and speciality shops;
- Discount department store and retail warehouses;
- Strip shopping along the street, up to 100 shops;
- Office component with office blocks; and/or
- Numerous and varied community facilities.

Figure 6.3 Location of suburban centres in Christchurch



Source: Based on Christchurch City District Plan, 2006

6.2 Christchurch City Urban Development Strategy

The Greater Christchurch Urban Development Strategy (GCUDS) is a collaborative initiative underway at the time of writing, involving a number of Councils and stakeholder agencies in the Christchurch area. Its key focus is to answer the question of how the Greater Christchurch community wishes to accommodate the predicted growth in population over the coming 30 - 40 years.

Geographically it is focussing on Christchurch city and the areas shaded in brown in Figure 6.2 and Figure 6.4, largely the coastal Canterbury area between the Ashley and Selwyn Rivers. The GCUDS must guide and integrate land use and infrastructure development (including transport infrastructure) as well as recognise and enable the community's economic, cultural, social and environmental values and desires.

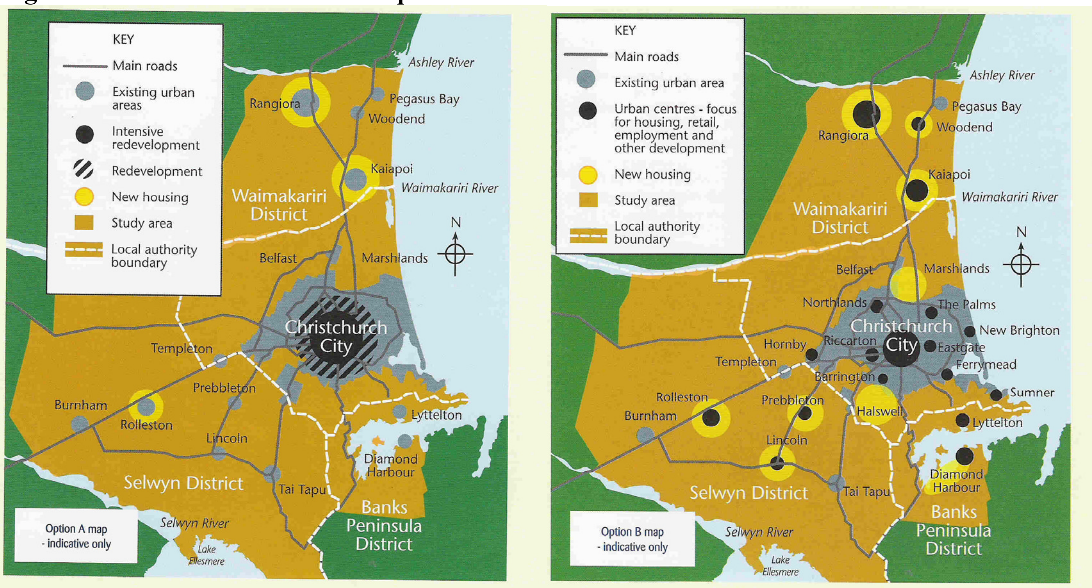
The population projections that are the foundation of this strategy development are, in summary, indicating a change from about 380,000 people in 2001 to about 430,000 in 2021 and about 500,000 in 2041 in the study area.

The development of the GCUDS is ongoing, but it has to date already involved considerable analysis and public engagement. In 2005, a major public consultation process involved the presentation of a number of potential future scenarios for the Greater Christchurch area with supporting information and analysis for each. Over 3,000 submissions were received on this material.

The analysis of the submissions showed substantial support for Option A (62%), a "consolidation" approach (for urban land and population distribution) and the majority of the remainder supported Option B (22%), a "concentrated" approach (Greater Christchurch Urban Development Strategy Forum, 2006 – 1). A "Business-as-usual" option received only 2% support, and an option involving a dispersed urban form received less than 2% support.

The favoured options (shown in Figure 6.4) have many common elements, which were reflected in regularly expressed comments. These included concerns related to protection and conservation of natural resources (water quality, open spaces, etc.), community character, energy efficient housing, good transport systems linking communities and more concentrated and planned development patterns including surrounding villages or town centres.

Figure 6.4 GCUDS Consultation Options



Option A **Option B**

In the analysis of submissions, the most frequent general feedback issues that touched on transport matters focussed on a desire for passenger rail (public transport) to be implemented, for urban centres to be designed around cycling and walking, and for alignment between land use and transport planning. In addition, analysis was undertaken on the feedback which addressed specific transport issues, and the final list of issues for the transport area:

- Cheap, efficient public transport should be given inner city priority and extended where necessary to cater for satellite towns and suburbs; with interchanges in key locations throughout the city;
- Repair/improve/extend cycleways, cycle lanes and cycle facilities;
- Promote the use of public transport, cycling and walking;
- Park (or cycle) and Ride systems should be implemented;
- Financial tariffs/incentives should be used to encourage the use of public transport; and
- Create a car-free inner city/reduce numbers of cars on the road;

A separate list of issues was created relating to passenger rail, and within that mention was made of introducing a rail-based Park and Ride system.

From this analysis of consultation feedback, the GCUDS project team proposes to develop a blend of the options A and B for analysis, leading to further consultation in the future. This would see a mixed concentrated/consolidated form for Christchurch with non-Christchurch growth focussed on the surrounding districts' townships. Initial discussions regarding this option have suggested that a principle of achieving excellent corridors for transport (providing high quality connections between nodes) should be followed, rather than continuous corridors of activity.

6.3 Trial Application of Assessment Framework to Christchurch

In terms of the Urban Form categories used in this project, the information for Christchurch presented in the previous section indicates that Christchurch does not fit neatly into one classification and is a mixture of urban form categories. The best classifications appears to be Type UF 3 (Radial/Concentric – Nodal) for the main urban area and Type UF 2 (Linear – Villages/Nodal) for the areas outside Christchurch. This mix exists currently although it is weakening. The UDS direction appears to be intending to strengthen this mix.

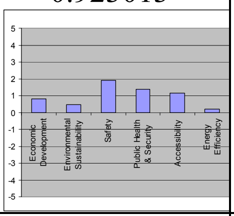
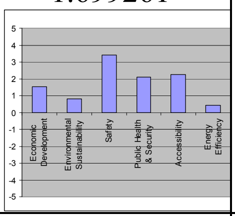
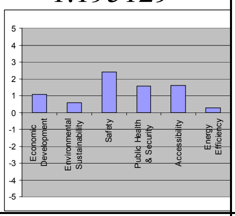
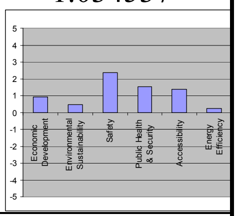
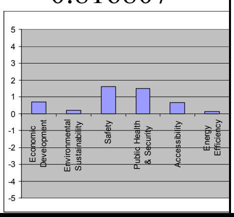
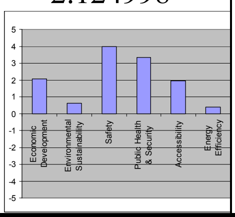
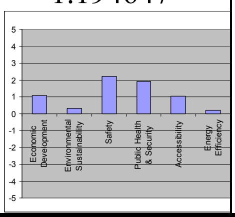
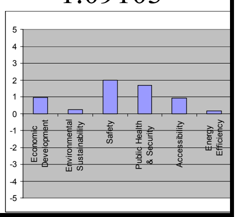
From the UDS consultation summary report material noted in the previous section, the priority objectives from the Assessment Framework Matrix profile for Christchurch appear to be Environmental Sustainability and Public Health & Security, with secondary priorities for Accessibility and Energy Efficiency.

With reference to the initial Assessment Framework Matrix (Table 3.8), the better performing Park and Ride categories are similar for both urban form category UF 2 (Linear – Villages/Nodal) and UF 3 (Radial/Concentric – Nodal) (based on the Weighted Summary Scores) with Type PR 2 (Link & Ride) clearly best performing, followed by Types PR 3 (Corridors), PR 6 (Nodal) and PR 1 (Necklace) in that order. From this assessment, clearly Park and Ride categories PR 4 (Dispersed) and PR 5 (Collar) are not appropriate, and with regard to Type PR 5 would create more costs than benefits to the city. Table 6.1 summarises the potential options for Christchurch.

By inspection of Table 6.1, it may be seen that all the profile indicators are positive for these two Park and Ride categories. However, the scores for the Environmental Sustainability indicator is not strong for any option, with Type PR 2 (Link & Ride) the best option but still with a score of less than one. Similarly, with one exception (cell UF 3/PR 2), the scores for Public Health & Security do not vary much and are essentially between 1 and 2. From these indicators there is no strong preferred option identified.

Given this situation, consideration of the secondary priority outcomes becomes more important. As with the two primary indicators, Energy Efficiency uniformly scores lowly (between zero and 0.5) and over a small range for all options. The Accessibility indicator however, does provide more variation. It is generally around or above one for all options, and the Type PR 2 (Link & Ride) category scores significantly better than the other categories for this indicator, with the Type 3 (Corridors) category clearly a second placed option.

Table 6.1 Initial Park and Ride category options for Christchurch

		Park and Ride Category			
		PR 1 Necklace	**PR 2 Link & Ride**	**PR 3 Corridors**	**PR 6 Nodal**
Urban Form Category	**UF 2** **Linear – Villages/ nodes**	0.923013 	1.699261 	1.195129 	1.034537 
	UF 3 **Radial/ Concentric – Nodal**	0.816807 	2.124998 	1.194647 	1.09103 

In terms of practical issues with the options for Christchurch, there are few strong activity corridors in Christchurch (with the exception of the east-west industrial belt following the rail line between Opawa and Hornby) so the Type PR 3 (Corridors) option would not be easily applied in a widespread fashion across Christchurch.

The major centres in Christchurch are generally too close (< 6-7 km) to the central city to be usable as the nodes for the Type PR 6 (Nodal) category. However, there are other nodes which could be developed for that purpose, should that category be desired.

From these considerations of the initial matrix, if a recommendation was to be made regarding the choice of a Park and Ride system type for Christchurch using the Assessment Framework, support could be given for the adoption of a choice from the Park and Ride categories PR 2 (Link & Ride), PR 6 (Nodal) or PR 1 (Necklace) in that order of preference. Type PR 2 (Link & Ride) is most likely to result in the best achievement of the city's urban form objectives.

Other significant considerations in the choice of Park and Ride system types for Christchurch relate to the non-geographical classification variables for Park and Ride systems identified in Section 3.2.2 Proposed Park and Ride Classification System". Details of the integration of a Park and Ride system with the wider Christchurch Metro public transport system would need some consideration in terms of potential impact on the scores contributing to the matrix. Perhaps more significantly is the issue of the integration of the Park and Ride system with the overall transport system, especially related to the generalised cost of trips by various modes and the control of parking in the central city. It is clear that there is so much easily available parking in the central city presently and a lack of quality priority for bus services that it would significantly reduce any potential benefits a Park and Ride system could provide for Christchurch. This should be reflected in a review of the Assessment Framework Matrix scores, and could easily see many indicators become negative, indicating that the Park and Ride systems may not be a useful addition to the Christchurch transport system. However that decision would also need to be taken in the light of an agreed set of (prioritised) objectives for the Park and Ride system against which it could be assessed and later measured.

6.4 Summary of Main Findings from the Case Study

Sufficient information is available for Christchurch to enable this case study to be undertaken using the Assessment Framework and methodology of this project. The following are the key findings from undertaking this case study:

- The urban form of Christchurch does not fit neatly into one of the defined urban form categories proposed in the Chapter 3. However, a mixed urban form scenario was able to be proposed for use in this case study;
- The Christchurch urban form data and priority objectives were able to be applied to the Assessment Framework Matrix;
- The case study results indicated that several Park and Ride categories may be applicable to Christchurch, with one category (PR 2 (Link & Ride)) appearing to be the optimal in terms of best achieving the urban form objectives;
- Consideration of the integration of a Park and Ride system with the wider public transport system and the importance of its implementation being part of a package of complementary transport measures and policies highlighted that the matrix should not be used in isolation or in a mechanical fashion;
- It should be highlighted that this trial application of the Assessment Framework to Christchurch is a case study and does not represent a definite recommendation to any party. However, it does indicate the process which may be applied; and
- To use this methodology in a recognised investigation would require development of agreed objectives by the decision-makers, undertaking the relevant objective preference and weighting processes, scoring the level three objectives with the best information currently available and for the decision-makers to commit to its success through the implementation of the other supporting complementary package of measures and policies.

Chapter 7 Findings, Conclusions and Further Study

This Chapter summarises the information presented in this report, providing an overview of the matters covered, discussion on the limitations and strengths of the work, proposals for further study and investigations related to this topic, and finishing with final thoughts and conclusions regarding whether the research project has achieved its original objectives.

Many cities are embarking on development or implementation of major land use development strategies, in an attempt to better manage the effects and opportunities of ongoing growth, which is placing increasing demands on the land use and transport systems.

Concurrently, Park and Ride is generating interest amongst the community and many community leaders as a possible measure to address the increasing pressures from the growing demands on the transport system. There has been no significant research undertaken of the interaction of Park and Ride systems and land use strategies, so there is little idea whether Park and Ride systems are a good and supportive, irrelevant, or bad and obstructive measure in seeking to achieve the objectives of land use strategies.

The fundamental aim of this project has been to attempt to develop a predictive framework which may assist in identifying Park and Ride system types that may support various desired urban forms.

A range of objectives and a research methodology were proposed and outlined for this project which was essentially a desk-top investigation and did not involve acquiring any new base data through fundamental market research, questionnaires, experiments or trials.

7.1 Main Findings

This section presents a brief overview of the findings presented in this report, broadly based on the structure of the report itself.

7.1.1 Literature and information review

- Park and Ride has been around for decades, and has perhaps existed in some (at least informal) form wherever there has been organised public transport systems in place.

- It is clear that there are a wide variety of different types of Park and Ride systems operating successfully in a wide variety of cities. To some degree, differences are apparent between countries as to how they implement and operate Park and Ride, such as between the UK and USA systems. The types and forms of Park and Ride vary from:
    - informal to formal;
    - stand-alone to integrated with the wider public transport system;
    - special-event based through seasonal operations to permanent;
    - independent initiatives through to systems that are fully integrated with other transport policy; and
    - bus to rail to ferry.

- As a consequence of historical as well as renewed recent interest in Park and Ride systems (to assist in dealing with growing transport demand), there has been considerable research and knowledge acquired on the operational aspects of the systems. This has resulted in a strong understanding of how to operate a Park and Ride system efficiently.

- There has been almost no research of substance into assessing Park and Ride systems against the objectives of the systems, notwithstanding that often the objectives are not clear if they exist at all.

- The lack of review and investigation against system objectives, or broader assessment of the "success" of systems against broader and general transport planning objectives has been at least in part contributed to through the way in which Park and Ride systems have been implemented. The implementation has often been piecemeal over a number of years, with other supporting transport system measures introduced in an ad hoc, uncoordinated manner also.

- The research undertaken for this project indicates that there has been no classification system proposed for Park and Ride systems at the system (typological) level. Some classifications systems have been found to allocate parking station types to a class within a system, but they do not relate to classifying the system itself.

- Despite unclear assessments as to the "success" of Park and Ride systems, once implemented, it is unlikely that there would be any significant political desire or community pressure to remove it. This appears to be caused by an implicit or explicit recognition that the Park and Ride system has added to the transport system supply, enabling certain trips. Removing the system would probably reduce the system supply, and may increase the generalised cost to travel even if the cost to supply the system reduces. Removal would also generally reduce accessibility to the key destination.

- Park and Ride has its critics, particularly in the UK. The main interest sector providing this criticism appears to be driven principally by the adverse impacts on the green belt and nearby countryside that they perceive are caused by the major parking stations at the periphery of the urban area.

- New Zealand has had Park and Ride systems in place for decades, but historically it has been largely informal or implemented as a relatively low key supporting measure for the public transport system (particularly ferries and commuter rail). It seems that it is only in the last decade or so that Park and Ride is being considered as a potentially important measure as part of a tool box of techniques to address growing travel demand and forming part of integrated transport strategies.

- Like the rest of the world, New Zealand does not have a well developed understanding of Park and Ride systems and has not undertaken much by way of strategic assessments of the existing systems. Consequently, there is also a poor level of clarity regarding the purpose and objectives of the Park and Ride systems in place or being considered.

- There has been some research and work undertaken regarding the establishment and changing structures of urban forms, although there has not been significant interest in this area for many years. Recent interest has been more in the area of what are the drivers and influences of change to urban form.

- Practitioners' comments and the presence of a range of projects and documents from around New Zealand clearly indicate that land use planning at a strategic level is gaining momentum in New Zealand. These initiatives are seeking to address a range of urban issues including transport, which are largely driven by population growth especially in larger urban centres. In these centres, a number of thresholds are being reached wherein key infrastructure and development decisions need to be made to ensure effective and efficient outcomes for the communities living there, as well as for the overall benefit of the country (such as not wishing to create any significant negative impacts on the national economy or environmental image).

- Urban form objectives can be identified from the generic urban geography literature and the individual urban development strategic studies from around New Zealand, which have generally been explicit in their objectives in one form or other. These objectives are usually presented in hierarchical structures and given various labels according to their place in the policy framework, such as outcomes, goals, objectives, policies, principles and the like.

- There are two basic types of decision-making – the single criterion and the multi-criteria. There are many methodologies within each basic type. In addition, within the multi-criteria methods, there are a range of options for weighting of objectives, and for giving opportunities to stakeholders to participate in decision-making. The Analytical Hierarchy Process is the most appropriate weighting process for use in the multi-criteria assessment framework developed for this project.

7.1.2 New Classification Schemes for Urban Form and Park & Ride systems

- A 7 category urban form classification system was derived for use in this project. Whilst this classification system was strongly based on that proposed by Thomson, it was also informed by other, classical urban form classification systems proposed during last century.

- A Park and Ride system classification scheme was also postulated for this research project. The proposed classification scheme was entirely novel.

- Park and Ride systems can be defined in terms of their key geographic, operational and strategic characteristics. The principal variable used in this classification system was the geographic distribution of the parking stations, of which 6 categories were identified. The Park and Ride system categories were assessed qualitatively against a list of 11 key objectives for Park and Ride systems.

7.1.3 Development of an Assessment Framework

- The key component of this study, and core to its methodology, was the creation of the Assessment Framework (and associated matrix) which provides an assessment of various types of Park and Ride schemes in assisting with the achievement of objectives for various urban forms. The matrix was populated using an analytical process that included input of scores for both the contribution to identified detailed urban form objectives by the various Park and Ride categories, and the establishment of the weightings between urban form objectives.

- The matrix was able to provide information and results for the possible combinations of urban form and Park and Ride categories (in 42 cells), with the results shown as a weighted summary score (from a multi-criteria analysis) and a profile of the level of achievement of high level objectives.

- The framework process allows significant input from stakeholders in the areas of weightings (through expressions of relative preferences between objectives) and the assignment of scores for contribution to achievement of objectives by the Park and Ride system categories.

- The application of the analytical process, including the classifications systems, to the real world was revealed as not necessarily being a simple or mechanical task, and may require some discretion and interpretation.

- The key issues revealed during the creation of the initial matrix related to the lack of good and accessible information to guide the scoring process and that there were some unusual and non-traditional combinations which had to be considered in the scoring process. These combinations presented a considerable challenge to score.

- Initial review of the draft Assessment Framework Matrix indicates that certain categories of Park and Ride systems generally (but not always) perform better than others in most urban forms, especially the Type PR 2 (Link and Ride) and Type PR 3 (Corridor) categories.

- Some urban forms do not appear to provide supportive environments for the operation of Park and Ride systems.

- In the initial matrix, there appears to be a correlation between the amplitude of the results shown in the indicator profile graph and the weighted summary score for each urban form/Park and Ride combination.

- The sensitivity tests undertaken indicated that the scoring of Park and Ride system performance against the level three objectives was a very important input to the assessment results which were highly sensitive to these scores. The strength of preference between objectives and the number of linkages between objectives were much less influential on the final results, although tests indicated that fewer linkages may allow better delineation between the individual profile indicators in the Assessment Framework Matrix.

- The Assessment Framework provided logical, intuitive and sensible results, which could be applied in a simple and transparent manner using both sets of information – the weighted summary scores and the outcome profile.

7.1.4 Testing the Assessment Framework Matrix

- A lack of data created limitations to the testing of the initial Assessment Framework Matrix against real cities.

- Six cities (two from New Zealand, two from the UK and two from the USA) were checked against the Assessment Framework Matrix, using available data, local knowledge and stated assumptions where needed.

- In most cases, the choice of Park and Ride system that is currently operating was identified as sound, if not always the optimal in terms of the matrix as it stands.

- This testing also reinforced that the key aspects of public transport integration and a supportive transport framework are important and, although considered as set to "optimal" in the Assessment Framework creation, different combinations could influence the final outcomes.

- The choice of urban form category could be important to decisions and perceived achievement of objectives.

- A further testing of the Assessment Framework on a range of hypothetical generic urban areas showed perhaps the most important outcome: that the Assessment Framework Matrix did not point to the same Park and Ride category irrespective of the urban form category being considered.

- Weighted Summary Scores proved to be a reliable first “sieve” to identify the best few Park and Ride categories which could be considered further at a more detailed assessment stage. However, this is a reasonable practice only whilst there is an observable correlation between the magnitude of the Weighted Summary Score and the amplitude of the indicator profile in each cell of the matrix.

- Some urban areas can present characteristics of more than one urban form category. These need careful assessment of the relative strengths of the different characteristics. In addition, consideration may be required of the future desired urban form as much as the current urban form.

- It was also necessary to give consideration to “practical” issues involved in a scenario, such as would the Park and Ride category provide an efficient arrangement of infrastructure for that urban form.

- Testing showed that where the difference between two or more Park and Ride options is small, especially in relation to priority outcome areas, the use of secondary priority profile indicators can provide additional information in helping to determine a decision. In those situations, it is also acceptable to recommend more than one potential solution from the assessment process (with appropriate supporting information and discussion) for a future choice by the decision-makers.

- The analysis undertaken in checking against real world cities and the hypothetical urban areas highlighted that there is a case to review or refine the scores in the spreadsheets contributing to the Assessment Framework Matrix, particularly as better information comes to hand.

7.1.5 A Case Study: Christchurch, NZ

- As in most real world situations, the urban form of Christchurch does not fit neatly into one of the defined urban form categories proposed in the Urban Form Classification system used in this project.

- A mixed urban form scenario was able to be proposed for use in this case study.

- The Assessment Framework Matrix indicated that several Park and Ride categories may be applicable to Christchurch, with one category (Type PR 2 (Link & Ride)) appearing to be the optimal in terms of meeting the urban form objectives.

- The integration of a Park and Ride system with the wider public transport system and the importance of its implementation being part of a package of complementary transport measures and policies was again highlighted. It was reinforced that the matrix should not be used in isolation or in a mechanical fashion.

7.2 Discussion

In this discussion section, various observations, experiences and knowledge taken from this project will be considered, as well as noting limitations that have been recognised.

As has been noted in many places throughout this research project, the information available on Park and Ride systems is almost exclusively related to operational matters or theoretical matters. There is very little information that can be readily found on any strategic review or assessment of Park and Ride systems. This situation not only makes it difficult for a project such as this one to produce confident results, more importantly, it makes it very difficult for decision-makers to make informed and objective decisions in relation to any Park and Ride systems for their jurisdiction. It also adds to the importance of undertaking research and analysis of strategic aspects of Park and Ride systems, such as this project has attempted to do.

After all the material presented in this project, questions will, properly, still be asked about how good is the Assessment Framework and how do we know the matrix is "right"? This is especially so given the lack of Park and Ride system data to inform the Assessment Framework, the wide variety of factors that make each city unique and that the assessment undertaken represents only the author's views. It was identified that many views from other stakeholders and/or professionals and practitioners being included in the assessments would improve confidence. The Assessment Framework has been set up to allow this input in a simple and transparent fashion.

It is acknowledged that many variables affect the "success" of Park and Ride systems, but this research project did not seek to identify nor quantify all those interactions. Those variables include the level of vehicle ownership, cultural views of the private motor car, the quality of the existing public transport system (including relative trip time between car-borne and bus based travel), density of population, legal and administrative structures, and the generalised cost of trip-making. This project focussed on creating and then assessing an Assessment Framework that for use in providing information on the choices between different Park and Ride system classifications in terms of their contribution to achieving the objectives of urban forms. The Assessment Matrix gives an initial indication of whether a Park and Ride system classification is likely to support or obstruct achievement of the objectives of various urban forms, and result in net benefits or costs to a city.

However, it is noted that creating the Assessment Framework Matrix from initial basic data and first principles is involved and time consuming, requiring the creation or review of 42 spreadsheets (for the combination of Park and Ride and Urban Form categories used in this project), but allows the uniqueness of a particular set of circumstances to be recognised. This level of input, however, would make the use of the methodology, from *first principles*, much less attractive to most users.

Irrespective of this, given the results of the checking against real cities and hypothetical urban areas as well as the case study, the results of the initial Assessment Framework Matrix appear to be intuitively and logically correct and consistent. For example, when the Auckland situation with its linear or radial corridors urban form in North Shore was applied to the Assessment Framework, the recommended Park and Ride systems were PR 3 (Corridors) or PR 2 (Link & Ride) which reflect the current Park and Ride system operating very successfully in that area.

A review of the draft Assessment Framework Matrix showed that for many Urban Form categories, the order of level of achievement of the Park and Ride categories was similar. From this observation, thought was given about whether groups of Urban Form categories could be combined for the matrix. However, this was not considered a wise development, as certain subtleties of scores and overlays of Park and Ride types to different Urban Form categories would be lost, notwithstanding that a certain degree of understanding of those subtleties is required of the analysts. As there are not many urban form categories, there was also no pressure to simplify the matrix by reducing the number of categories.

As with many methodologies seeking scoring by stakeholders or interested parties, there are several potential biases which may be observed in the scores provided. In this project, this issue was addressed indirectly through the sensitivity tests. These showed that for the process which provided weightings for the objectives, the distribution of scores appeared to not be a strong influence on the final outcomes but that the direction of the preference appeared important. This issue is probably also influenced by the degree of linkages between objectives at the different levels. However, the scores provided for Park and Ride system achievement of the level three objectives was very influential on the final results. This would not cause a problem in a situation where only one set of scores where provided and considered, but where different groups or people were individually providing inputs that created parallel matrices, then much care would be needed to compare and normalise the results so that they could be compared with each other.

The linkage tables in the Assessment Framework currently show many connections between objectives, irrespective of whether they were strong or weak. Sensitivity tests indicated that there are so many linkages that the input scores are being considerably diluted and spread across the profile indicators. This results in a similar profile shape irrespective of the individual scores and the profile amplitude reflects the total score sum. More recognition of the strong connections and more discernment between indicator objectives may be achieved through a reduction of the number of linkages to retain only the strong linkages. A pair-wise comparison process (AHP) could be undertaken with the linkages to establish the key linkages and to determine which ones to omit.

Another question arose during the checking against hypothetical urban areas, which was “Can the Assessment Framework Matrix indicate when a Park and Ride category is a bad idea for a city?” The simple answer is yes. Clearly, when all the indicators in the outcome profile are positive, then the category could produce a good result for the city, and when the indicators are all negative it would appear that the Park and Ride category would produce dis-benefits in all objective areas being sought for the city. However when some indicators are positive and others are negative, it would be a matter of assessing how the results relate to the priority objectives and any strategic policy thresholds, as well as the relative benefits and costs across the outcome indicators.

Given the specific nature of ferry-based park and ride, no classification has been attempted in this project. However, ferry-based Park & Ride is most similar to the “Necklace” type system, with an independent service.

Similarly, for the purposes of this project, there has been no attempt to classify temporary Park and Ride systems, which are established for short-term demands such as sporting events, seasonal attractions or major infrequent attractions. However, it may be possible that the temporary systems could be classified using the proposed classification system for permanent schemes.

7.3 Suggestions for Improvements and Further Study

In the course of developing and reviewing the material in this project a number of potential improvements or options for further study have become apparent. They cover:

- **Improved information:** Throughout the project, the level of available and useful information was consistently an impediment. So a key improvement area would be to seek out better information and sources to allow more confidence in the inputs to the framework. Some which probably exists, but was beyond the limits of this project, would be better data for real cities against which the Assessment Framework Matrix may be validated. In a similar vein, trialling the overall process (AHP weightings and scoring of objectives) with actual stakeholders in real or hypothetical circumstances would be productive (even if to establish that such input is not critical or required).

  The literature and information review concentrated on Park and Ride information from the UK, the USA, Australia and New Zealand, particularly in terms of reviewing the actual systems themselves. Some information was reviewed from Asian sources, but no Asian systems were reviewed. There may be some value in gaining better insights into Park and Ride as it operates in Asia, although this may have limited value in its application to the New Zealand situation.

  Given the recognition of the variety of factors that could influence the success of a Park and Ride system, there may be value in exploring whether certain factors are consistently important to some specific Park and Ride system classification types (rather than for all Park and Ride systems), and hence may influence the results in the Assessment Framework matrix.

  Simplify the spreadsheet: As noted previously, the current spreadsheet is involved and time-consuming to complete all the preference and score inputs. It would be worth exploring simplification of the urban form objectives in the spreadsheet, especially through reducing the number of levels of objectives.

A second means of simplifying the spreadsheet is to provide better definitions of all the categories in the two typologies being used as well as full definitions of all the objectives and their contributions and linkages to other objectives, perhaps in a "User Manual". This would allow better understanding of the various elements and more knowledgeable, confident and repeatable inputs from various stakeholders and interest groups.

A third option for simplifying the spreadsheet is to identify which input areas are quantitative and which are qualitative. For each quantitative input, an objective scoring regime could be established e.g. a score of -3 might equal a reduction in performance of 10% or more, a score of -2 is a reduction of between 5% and 10%, etc. This would make scoring reliant upon good quality data for these inputs, but they would then not require input from stakeholders or other interested parties, thus reducing the input demands for the process. For the qualitative inputs, guidelines could be established defining what each score could mean for each input area. Whilst this would not reduce the input load on contributors or stakeholders, it would reduce any potential stress and confusion that may arise concerning the gradation of the scores and how they should be applied. From the perspective of the results and repeatability of process, this would reduce potential sources of bias and variability between stakeholders and/or other contributors.

The fourth and final potential simplification of the spreadsheet involves considering the reduction in the range of scoring options, with particular reference to the scale used in the AHP objective weighting process currently. This is currently a 9 point scale. As the sensitivity tests indicated that the quantum of the score for this area is not strongly influential in the current spreadsheet (but the direction is influential), it would be worth testing how a reduction to a 7 point scale may affect the outputs (from reduced choices). The other related option to explore could be to test the effects of using the alternative text-to-numbers conversion table (see Table 2.3).

Urban Form Classifications: It is apparent from the various applications of the Assessment Framework Matrix conducted as part of this project that there are many situations where an urban form does not fit into one urban form category as proposed in this project. There are some regular occurrences or combinations that have been encountered, which raise the issue of whether there may be additional categories or whether a slight readjustment of the classification system is warranted. The most regular exception appears to be satellite townships existing outside but reliant upon the main urban area that create a noticeable transport demand on that main urban area. However there is only one category which currently includes satellite townships (Type UF 2). Therefore, considering the introduction of options to recognise this would reduce the frequency of mixed urban form categories being evaluated and make use of the matrix more straightforward (despite it potentially being bigger and more extensive to create).

Objectives Review: Whilst not fundamental to the basis of this project, further work could be undertaken to refine Table 3.2 Urban Form Category Objectives. The scores proposed in Table 3.2 are not derived from a rigorous research process or through extensive consultation with either experienced practitioners or the communities of these categories of urban form. They are simply the first cut view of the author, informed by the research undertaken in this project, and professional experience in the land use/transport planning field.

In addition and to assist with the previously suggested work, further work on definitions of the objectives would be useful for both stakeholders and practitioners to better understand the objectives when trying to explain or provide views and inputs on preferences and relative weights. Investigation work for this project clearly indicated that some scoring and comparisons were difficult due to the inter-relationships and overlapping definitions or issues of various objectives even when they are at the same level. This is particularly important if the process is to be used with real world situations and stakeholders.

Objectives weighting: The Assessment Framework spreadsheets adopted the original AHP descriptor: score equivalence table for the production of weightings of the objectives. As noted in Table 2.3 AHP weighting table, there is an alternative equivalence table, entitled the Balanced Score Scale. There could be value in undertaking a simple sensitivity test based on use of this alternative scale, to assess the impact of the choice of scales. Given that the sensitivity test undertaken in this research project which investigated the importance of the strength of the preferences did not show a strong impact, it is unlikely that use of the Balanced Score Scale in the current Assessment Framework spreadsheets would show significantly different results.

Versions of the Matrix: Earlier discussion raised a question about whether a single Assessment Framework Matrix is sufficient or whether there is a need to create a new one for each situation or urban area? The case was made for two types of matrix, based on who is using the matrix. The two types were a "master" or reference matrix, which can be used by practitioners and professionals when conducting technical reviews and analysis, and an allied "stakeholder" matrix that could be used as a template to create a new matrix for each urban area or each investigation, to which the stakeholders, affected communities and local decision-makers contribute.

It is suggested that a reference matrix should be developed from this methodology and then progressively improved through updates and periodic review as more information comes to hand and successive applications provide more feedback. This reference matrix could contain a series of standardised scores for the level three objectives, along with (averaged) objective preferences/weightings for the various urban forms derived from inputs of a wide range of stakeholders and decision-makers from all types of urban forms over time. It could also be used as the "template" matrix for stakeholder processes, rather than requiring contributors to a process to start from scratch with an empty matrix and an imposing suite of spreadsheets to be filled in. As noted earlier, for the process to be attractive, it must be simple, accessible, robust, reliable and understandable. If it is not, it is unlikely to be used, or if used, it may not be relied upon.

Use with Rail-based Park and Ride systems: Developing the issue of the universality of the Assessment Framework Matrix further raises the question of whether rail-based Park and Ride systems achieve the urban form objectives differently to bus-based Park and Ride, and if so, then how and why?

A parallel closely related question is "are rail-based Park and Ride systems inherently more successful than bus based systems?" Potentially characteristics of speed, comfort, capacity and cost could be significant and lead to initiatives for making bus based systems more successful.

7.4 Conclusions and Final Comments

The key conclusion to be drawn at this point is that the project has achieved its original objectives and goals. It has produced a process to analyse, at least in part, the performance and impact of Park and Ride systems on different urban forms.

The literature and information review provided evidence that there is a place and need for a rational assessment of Park and Ride systems at the systems level in light of the often restricted resources for transport investment and the need to maximise the probability of the systems assisting the achievement of the objectives of land use planning in urban areas. This research project can contribute to resolving that need.

The work done as part of this project indicates that the Assessment Framework Matrix methodology could be used as a predictive tool insofar as indicating how Park and Ride system categories could perform relative to one another in a particular situation or location. The use of the Assessment Framework Matrix as proposed in this project has proven to be reasonably straightforward and objective, and it has produced intuitive and sensible results. From the testing of this project's initial matrix on real cities and hypothetical urban areas, it can be concluded that the matrix has provided sound insights and information in relation to the situations assessed. Subject to refinement or review of the inputs to the spreadsheets, it should be able to be used with a degree of confidence to inform investigations of the most appropriate types of Park and Ride systems for particular urban areas.

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Appendices

Appendix 1: The Basics of the Delphi Method

Appendix 2: Urban Form Type Diagrams

Appendix 3: Park and Ride Geographical Distributions Diagrams

Appendix 4: Initial Assessments of Park and Ride System Categories

Appendix 1 The Basics of the Delphi Method

The **Delphi method** is a systematic interactive forecasting method based on independent inputs of selected experts. The technique allows experts to deal systematically with a complex problem or task. It comprises a series of questionnaires sent either by mail or via computerised systems, to a pre-selected group of experts. These questionnaires are designed to elicit and develop individual responses to the problems posed and to enable the experts to refine their views as the groups work progresses in accordance with the assigned task. The main point behind the Delphi method is to overcome the disadvantages of conventional committee action. The group interaction in Delphi is anonymous, in the sense that comments, forecasts, and the like are not identified as to their originator but are presented to the group in such a way as to suppress any identification.

The Delphi method recognizes the value of expert opinion, experience and intuition and allows using the limited information available in these forms, when full scientific knowledge is lacking.

Delphi method uses a panel of carefully selected experts who answer a number of rounds of questionnaires. Questions are usually formulated as hypotheses, and experts state the time when they think these hypotheses will be fulfilled. Each round of questioning is followed with the feedback on the preceding round of replies, usually presented anonymously. Thus the experts are encouraged to revise their earlier answers in light of the replies of other members of the group. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. After several rounds the process is complete and the median scores determine the final answers.

The person co-ordinating the Delphi method can be known as a *facilitator*, and facilitates the responses of their *panel of experts*, who are selected for a reason, usually that they hold knowledge on an opinion or view. The facilitator sends out questionnaires, surveys etc. and if the panel of experts accept, they follow instructions and present their views. Responses are collected and analysed, then common and conflicting viewpoints are identified. If consensus is not reached, the process continues through thesis and antithesis, to gradually work towards synthesis, and building consensus.

The following key characteristics of the Delphi method help the participants to focus on the issues at hand and separate Delphi from other methodologies:

1. Structuring of information flow
2. Regular feedback
3. Anonymity of the participants

Structuring of information flow

The initial contributions from the experts are collected in the form of answers to questionnaires and their comments to these answers. The panel director (or facilitator) controls the interactions among the participants by processing the information and filtering out irrelevant content. This avoids the negative effects of face-to-face panel discussions and solves the usual problems of group dynamics.

Regular feedback

Participants comment on their own forecasts, the responses of others and on the progress of the panel as a whole. At any moment they can revise their earlier statements. While in regular group meetings participants tend to stick to previously stated opinions and often conform too much to group leader, the Delphi method prevents it.

Anonymity of the participants

Usually all participants maintain anonymity. Their identity is not revealed even after the completion of the final report. This stops them from dominating others in the process using their authority or personality, frees them to some extent from their personal biases, minimizes the "bandwagon effect" or "halo effect", allows them to freely express their opinions, encourages open critique and admitting errors by revising earlier judgments.

The following ten steps are representative of the Delphi method:

1. Formation of a team to undertake and monitor a Delphi on a given subject.
2. Selection of one or more panels to participate in the exercise. Customarily, the panellists are experts in the area to be investigated.
3. Development of the first round Delphi questionnaire.
4. Testing the questionnaire for proper wording (e.g. ambiguities, vagueness).
5. Transmission of the first questionnaires to the panellists.
6. Analysis of the first round responses.
7. Preparation of the second round questionnaires (and possible testing).
8. Transmission of the second round questionnaires to the panellists.
9. Analysis of the second round responses (Steps 7 to 9 are re-iterated as long as desired or necessary to achieve stability in the results).
10. Preparation of a report by the analysis team to present the conclusions of the exercise.

Overall the track record of the Delphi method is mixed. There have been many cases when the method produced poor results. Still, some authors attribute this to poor application of the method and not to the weaknesses of the method itself. It must also be realised that in areas such as science and technology forecasting the degree of uncertainty is so great that exact and always correct predictions are impossible, so a high degree of error is to be expected.

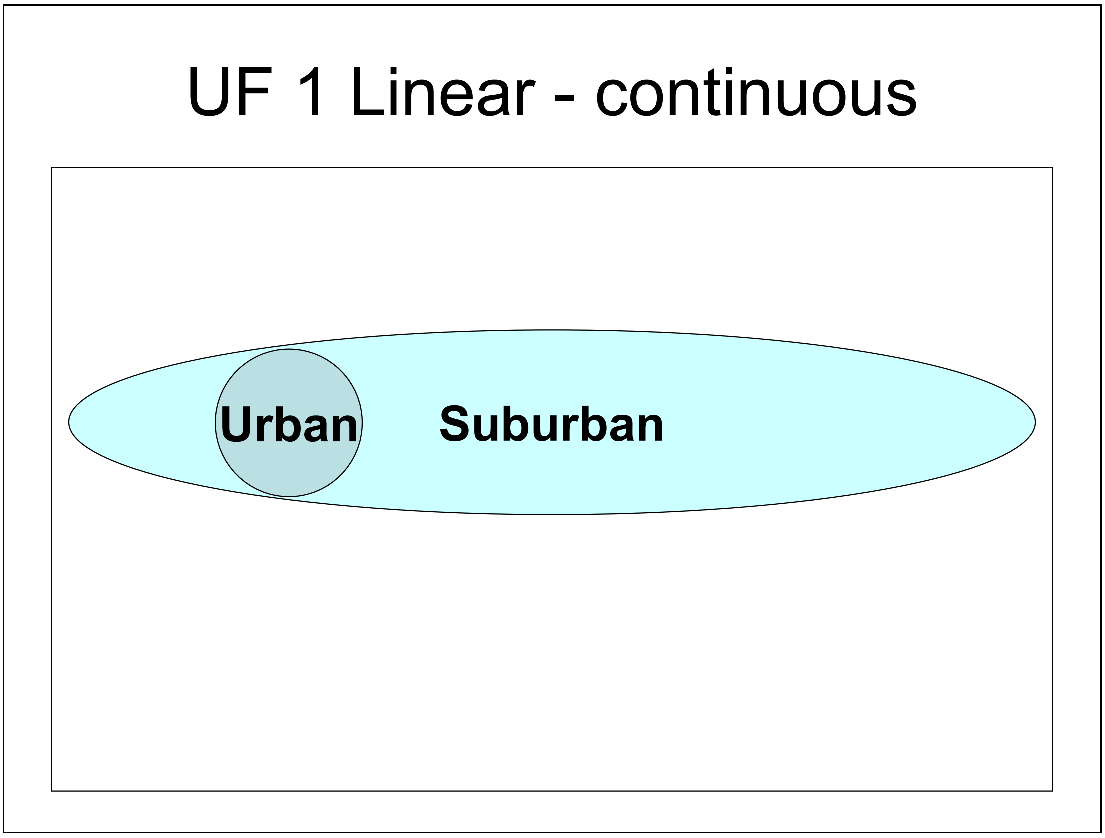
Another particular weakness of the Delphi method is that future developments are not always predicted correctly by iterative consensus of experts, but instead by unconventional thinking of amateur outsiders.

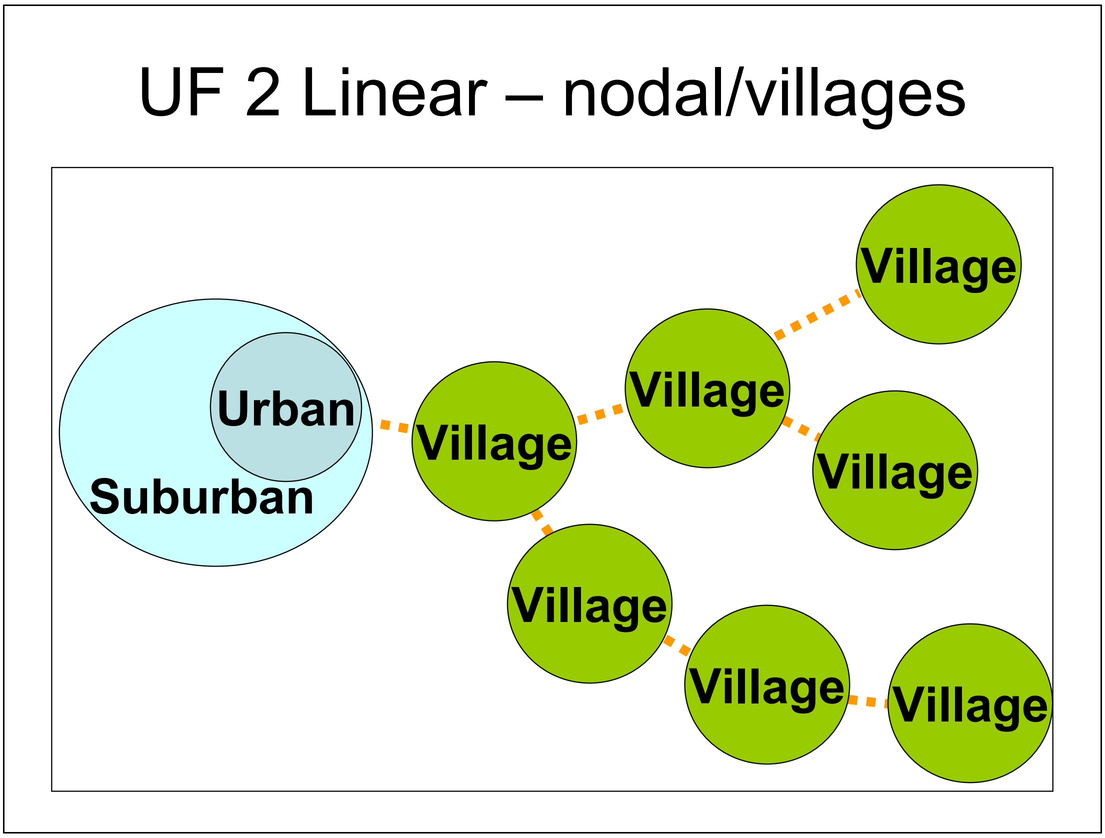
One of the initial problems of the method was its inability to make complex forecasts with multiple factors. Potential future outcomes were usually considered as if they had no effect on each other. Later on, several extensions to the Delphi method were developed to address this problem, such as cross impact analysis, that takes into consideration the possibility that the occurrence of one event may change probabilities of other events covered in the survey. Still the Delphi method can be used most successfully in forecasting single scalar indicators.

Despite these shortcomings, today the Delphi method is a widely accepted forecasting tool and has been used successfully for thousands of studies in areas varying from technology forecasting to drug abuse.

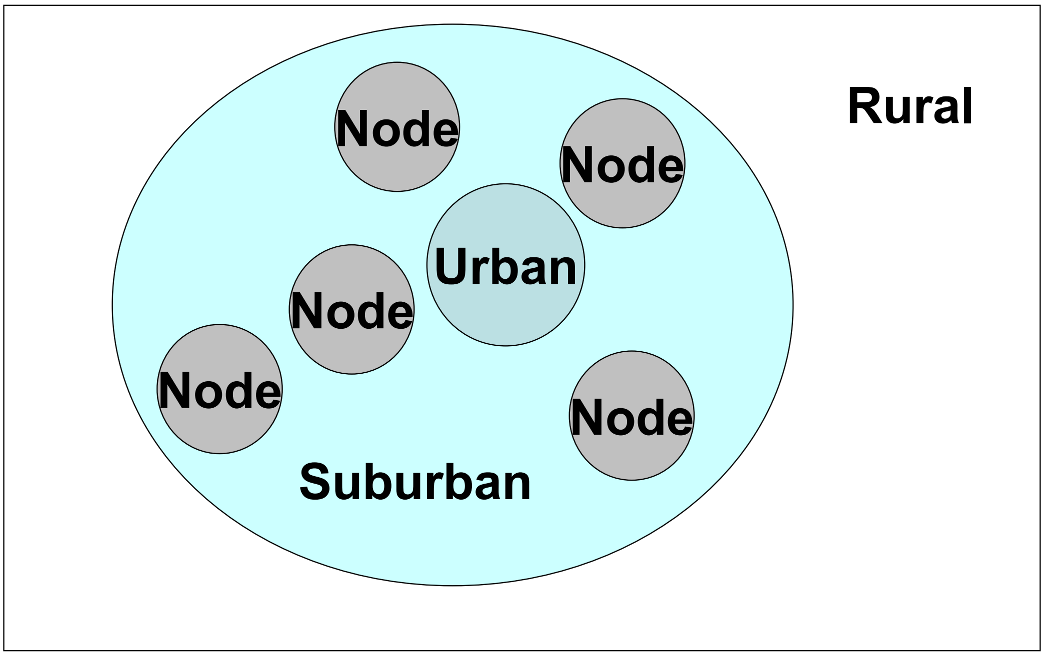
Summarised from <http://en.wikipedia.org/wiki/Delphi_method> and <http://www.iit.edu/~it/delphi.html>

Appendix 2 Urban Form Type Diagrams

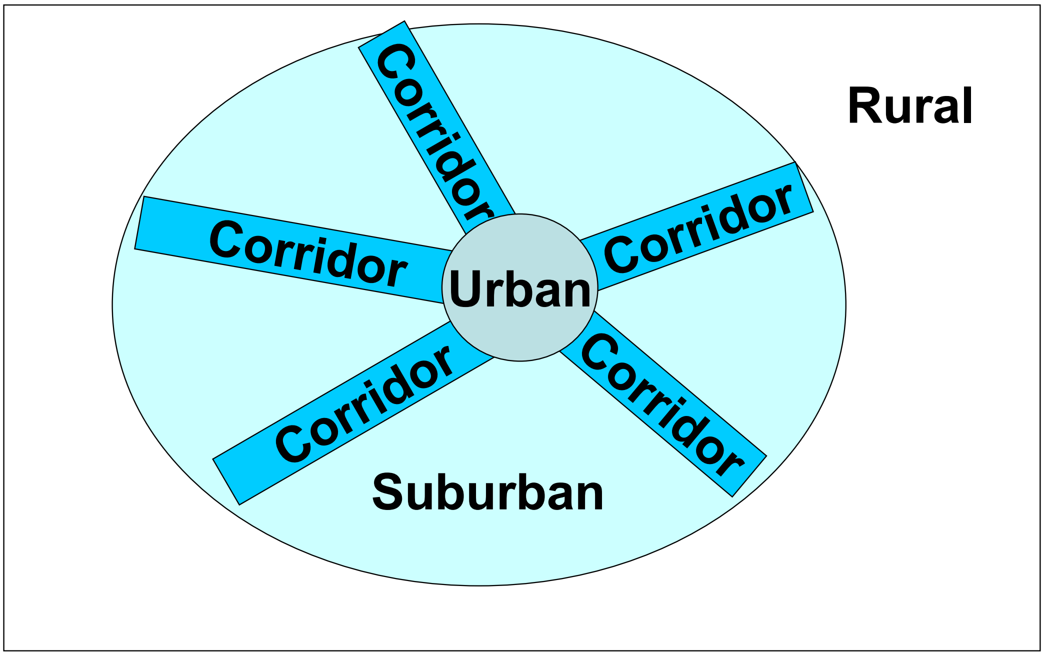




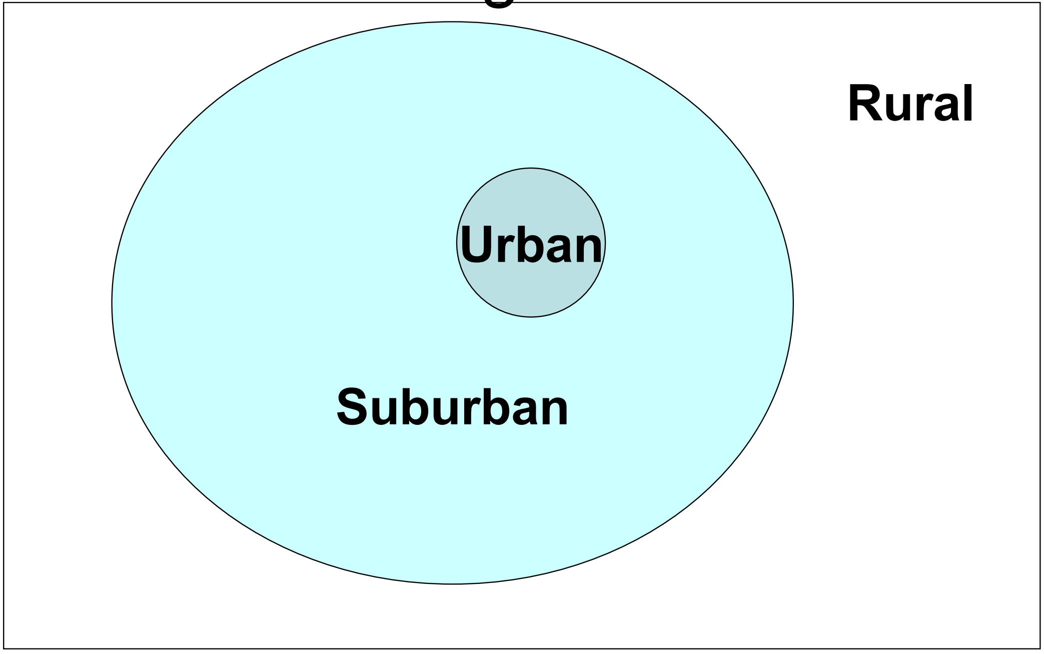
UF 3 Radial/Concentric - Nodal



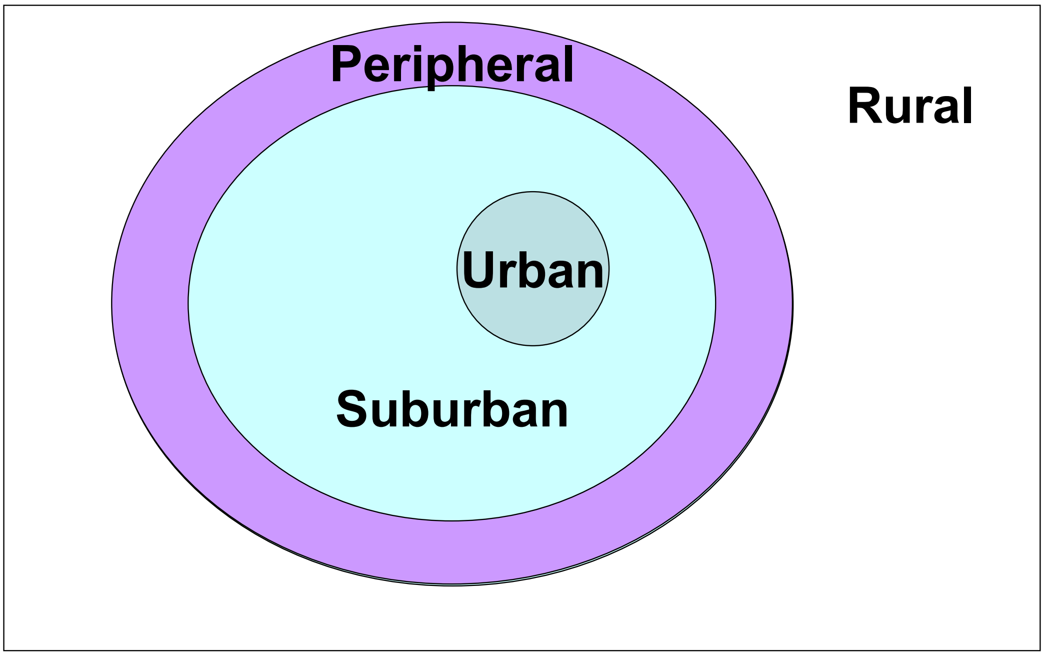
UF 4 Radial/Concentric - Corridors



UF 5 Radial/Concentric - Homogeneous



UF 6 Radial/Concentric - Peripheral

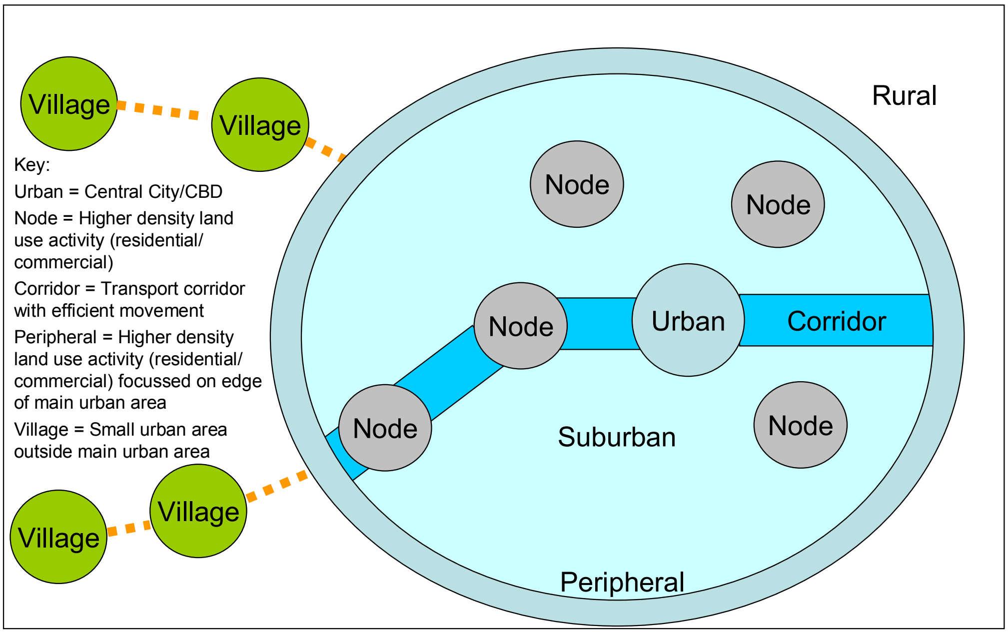


UF 7 Dispersed

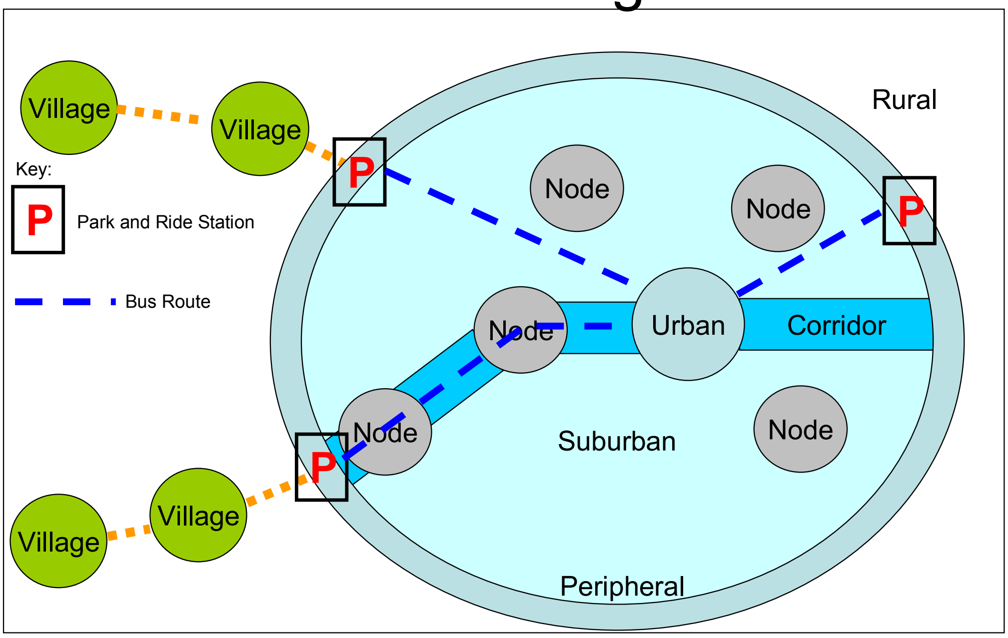
Low density homogeneous suburban/rural

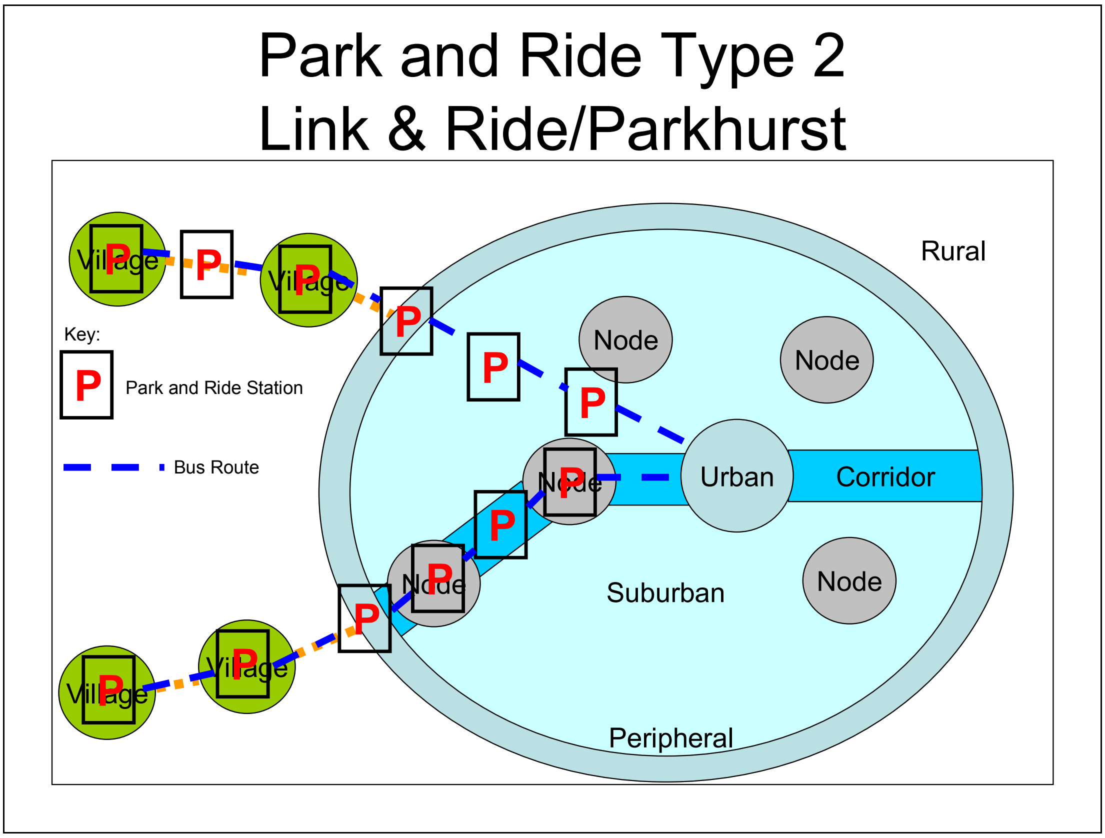
Appendix 3 Park & Ride Geographical Distributions Diagrams

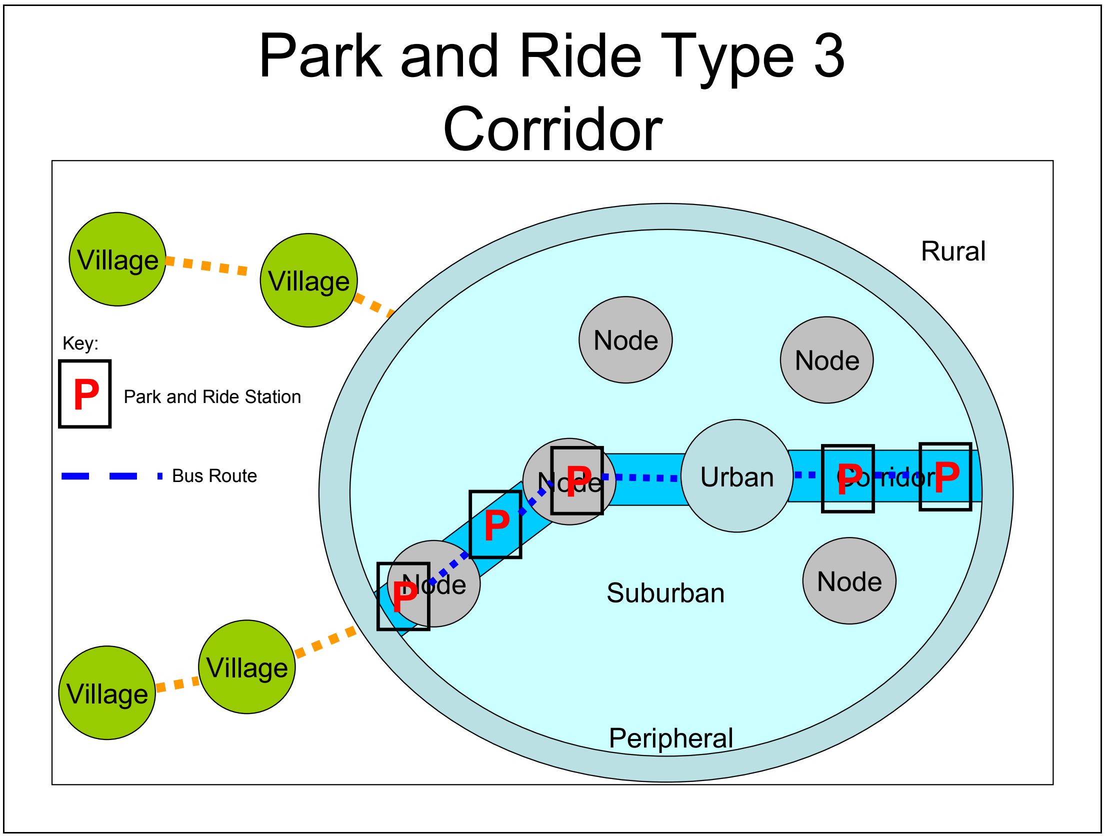
Universal Landform Template

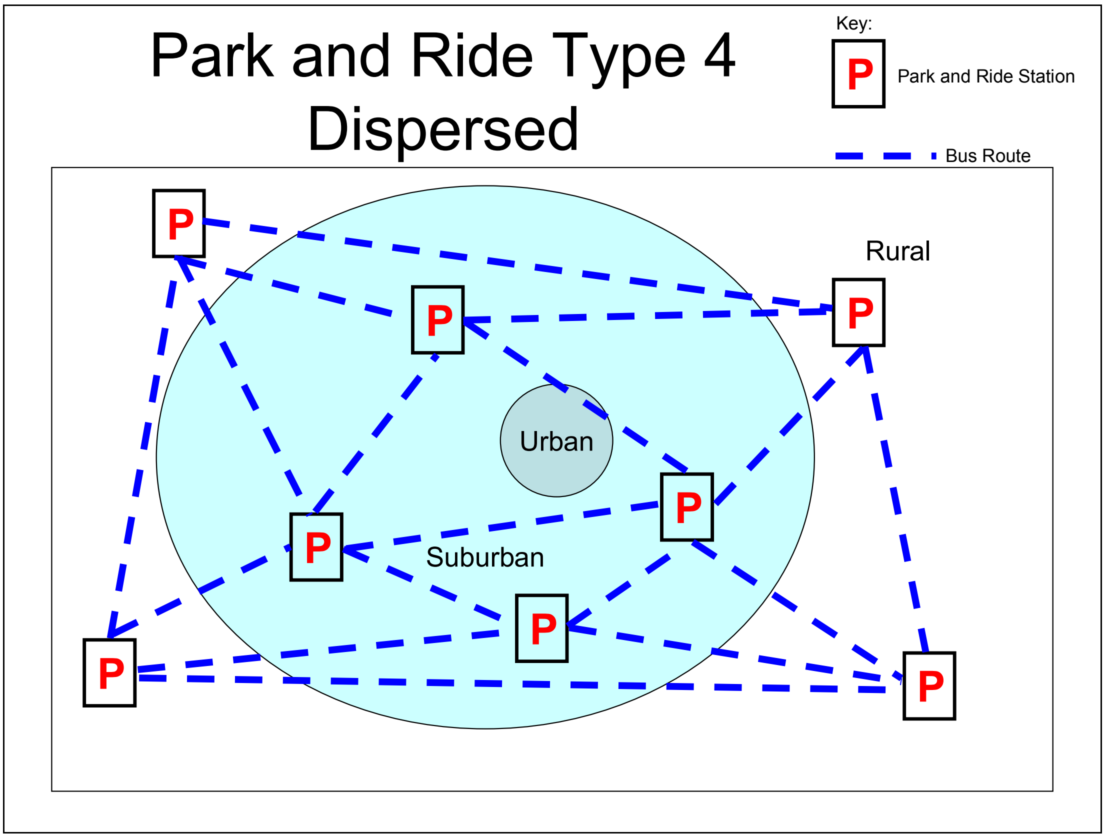


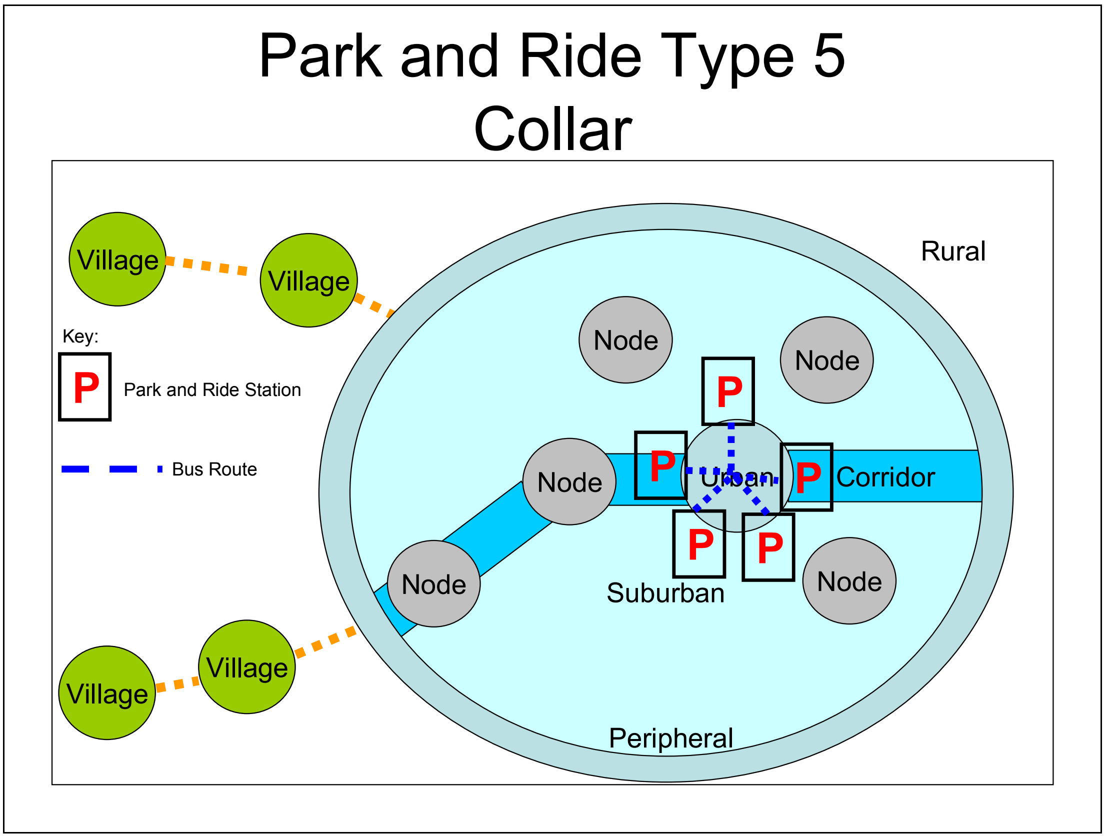
Park and Ride Type 1 Necklace/English

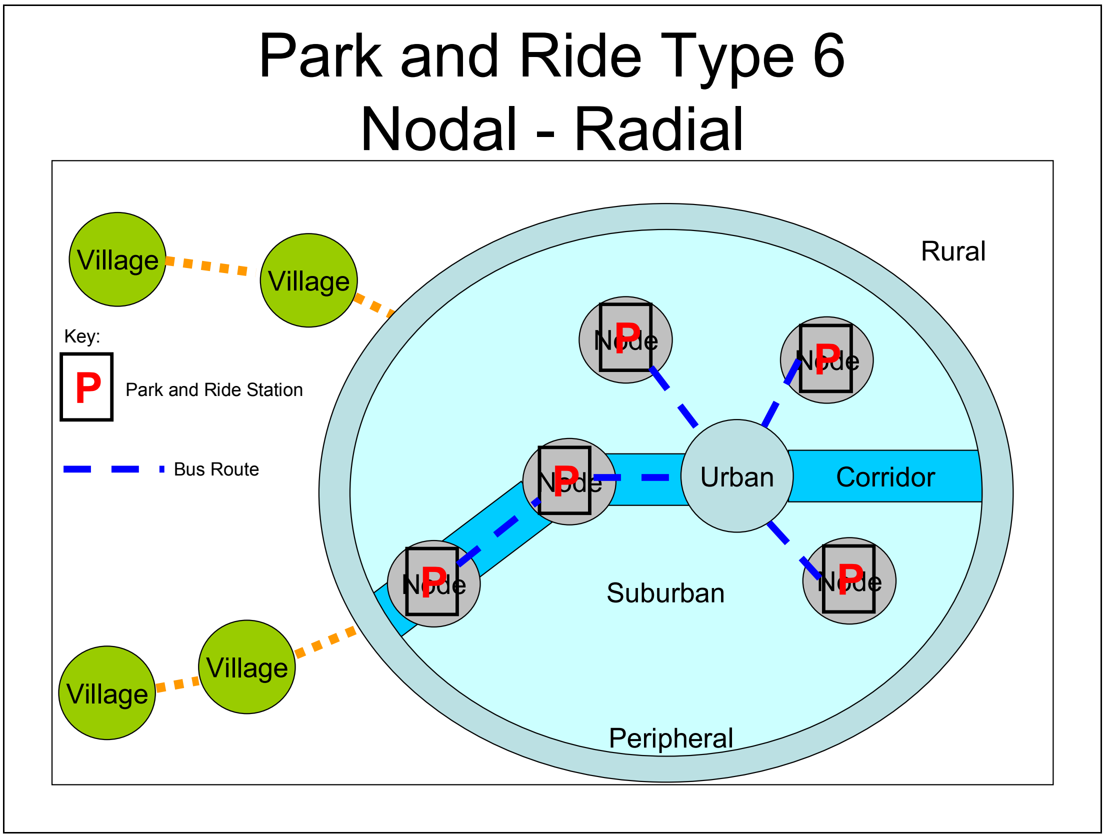



Park and Ride Type 2
Link & Ride/Parkhurst
Village
Village
Village
Village
Key:
Park and Ride Station
Bus Route
Rural
Node
Node
Node
Node
Node
Urban
Corridor
Suburban
Peripheral


Park and Ride Type 3
Corridor
Village
Village
Village
Village
Key:
Park and Ride Station
Bus Route
Rural
Node
Node
Node
Node
Node
Urban
Corridor
Suburban
Peripheral


Park and Ride Type 4
Dispersed
Key:
P
Park and Ride Station
Bus Route
Rural
Urban
Suburban
P


Park and Ride Type 5
Collar
Village
Key:
P
Park and Ride Station
Bus Route
Rural
Node
Urban
Corridor
Suburban
Peripheral
P


Park and Ride Type 6
Nodal - Radial
Village
Village
Key:
P
Park and Ride Station
Bus Route
Rural
Node
P
Urban
Corridor
Suburban
Peripheral
Village
Village

Appendix 4 Initial Qualitative Assessments of Park & Ride System Categories

Table 0.1 Initial assessment of Objectives by Park & Ride Type – Necklace

Park and Ride Type: Necklace	
Example	Oxford, UK; Shrewsbury, UK
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is needed in the central city area, releasing land for more productive and efficient development.
More cost-effective provision of parking for central city	For a given level of parking provision supporting the central city, it will be cheaper to provide some parking at the park and ride stations with cheaper development costs than in the higher cost centre.
More economically efficient transport system	For a given travel demand, it is likely that the transport system will be more economically efficient. Private trips are made in less congested conditions with public transport travel occurring in the more congested areas (presuming some public transport priority). However this may be off-set to some degree if greater private vehicle travel occurs in accessing the parking stations (urban dwellers back-tracking to the stations, to go forward by bus). Overall the generalised cost of travel is likely to have lowered.
Reducing congestion levels on urban radial routes	For a given level of demand, some reduction in congestion should occur. However, no examples have ever been cited, and generally the released supply is absorbed by new (in some places, suppressed demand) trips.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled.
Reducing the need/pressure for increased road capacity	A temporary fix, as even with very successful systems, the reduced demand may represent up to 5 years of traffic growth. It would depend upon the nature and location of the growth and types of network improvements needed. Improvements for public transport priority will almost certainly be required.
Increases public transport use	Depends upon whether the system is integrated with general public transport. Isolated services operate in competition with general public transport, but there appears to be overall more people catching the bus/train despite being split between systems. Integrated systems clearly provide some benefit, but the degree is unclear.

Reducing local emissions/ pollution levels	Will depend upon the degree of congestion relief experienced with the system, but as congestion relief is not observed, reductions in emissions are not likely at the local level.
Reducing transport greenhouse production	Will depend upon the balance between reducing local congestion problems and the growth in overall vehicle travel. May well see an increase
Reducing other environmental impacts (e.g. noise)	As with other environmental objectives, no major improvements could be expected as a rule although in specific cases and locations some improvements may occur. Adverse effects of parking stations locating in green belts are a key concern of some groups.
Increase social inclusion/ community liveability	Increased social contact and possibly some reduced vehicle travel impacts in key congested corridors through the use of public transport could be expected. Greater vehicle travel around the parking stations would potentially create adverse traffic effects on the local community.

Table 0.2 Initial assessment of Objectives by Park & Ride Type – Link & Ride

Park and Ride Type: Link & Ride	
Example	Wellington Rail Park & Ride
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is needed in the central city area, releasing land for more productive and efficient development.
More cost-effective provision of parking for central city	For a given level of parking provision supporting the central city, it will be cheaper to provide some parking at the park and ride stations with cheaper development costs than in the higher cost centre. A number of smaller parking stations will be easier to find sites than for much larger stations, but set-up overheads costs may counter these savings.
More economically efficient transport system	For a given travel demand, it is likely that the transport system will be more economically efficient. Private trips are made in less congested conditions with public transport travel occurring in the more congested areas (presuming some public transport priority). Relatively short private vehicle trips to the wide range of potential sites reduces the overall proportion of private vehicle travel to public transport travel. Overall the generalised cost of travel is likely to have lowered.

Reducing congestion levels on urban radial routes	For a given level of demand, some reduction in congestion should occur. However, no examples have ever been cited, and generally the released supply is absorbed by new (in some places, suppressed demand) trips. Less private travel accessing the parking stations also reduces some use of arterials to access the stations.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled.
Reducing the need/pressure for increased road capacity	A temporary fix, as even with very successful systems, the reduced demand may represent up to 5 years of traffic growth. It would depend upon the nature and location of the growth and types of network improvements needed. Improvements for public transport priority will almost certainly be required. Less pressure on road network immediately surrounding the parking stations is likely, through lower demand per station.
Increases public transport use	Depends upon whether the system is integrated with general public transport, although generally it is integrated. Isolated services operate in competition with general public transport, but there appears to be overall more people catching the bus/train despite being split between systems. Integrated systems clearly provide some benefit and growth, but the degree is unclear.
Reducing local emissions/ pollution levels	Will depend upon the degree of congestion relief experienced with the system, but as congestion relief is not observed, reductions in emissions are not likely at the local level. Less travel by private vehicle would generate lower emission levels, although this will not be linear due to a greater proportion of private vehicle trips occurring while the engine is still cold
Reducing transport greenhouse production	Will depend upon the balance between reducing localised congestion problems and the growth in overall vehicle travel. With greater proportion of private vehicle travel over short distances with cold engines, any improvements will not be linear.
Reducing other environmental impacts (e.g. noise)	As with other environmental objectives, no major improvements could be expected as a rule although in specific cases and locations some improvements may occur. Smaller parking stations should create fewer environmental effects through good design.

Increase social inclusion/ community liveability	Increased social contact and possibly some reduced vehicle travel impacts in key congested corridors through the use of public transport could be expected. Some increase in vehicle travel around the parking stations would potentially create adverse traffic effects on the local community. More parking stations make accessing the system by foot or cycle more possible (but not a focus of the park and ride system!)

Table 0.3 Initial assessment of Objectives by Park & Ride Type - Corridor

Park and Ride Type: Corridor	
Example	Auckland BRT/Busway; Leeds (UK) Tram
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is needed in the central city area, releasing land for more productive and efficient development.
More cost-effective provision of parking for central city	For a given level of parking provision supporting the central city, it will be cheaper to provide some parking at the park and ride stations with cheaper development costs than in the higher cost centre. A number of smaller parking stations will be easier to find sites than for much larger stations, but set-up overheads costs may counter these savings.
More economically efficient transport system	For a given travel demand, it is likely that the transport system will be more economically efficient. Private trips are made in less congested conditions with public transport travel occurring in the more congested areas (presuming some public transport priority). Relatively short private vehicle trips to the wide range of potential sites reduces the overall proportion of private vehicle travel to public transport travel. Overall the generalised cost of travel is likely to have lowered.
Reducing congestion levels on urban radial routes	For a given level of demand, some reduction in congestion should occur. However, no examples have ever been cited, and generally the released supply is absorbed by new (in some places, suppressed demand) trips. Less private travel accessing the many parking stations also reduces some use of arterials to access the stations.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled.

Reducing the need/pressure for increased road capacity	A temporary fix, as even with very successful systems, the reduced demand may represent up to 5 years of traffic growth. It would depend upon the nature and location of the growth and types of network improvements needed. Improvements for public transport priority will almost certainly be required. Less pressure on road network immediately surrounding the parking stations is likely, through lower demand per station.
Increases public transport use	Depends upon whether the system is integrated with general public transport, although generally it is integrated. Isolated services operate in competition with general public transport, but there appears to be overall more people catching the bus/train despite being split between systems. Integrated systems clearly provide some benefit and growth, but the degree is unclear.
Reducing local emissions/ pollution levels	Will depend upon the degree of congestion relief experienced with the system, but as congestion relief is not observed, noticeable reductions in emissions are not likely at the local level. Less travel by private vehicle would generate lower emission levels, although this will be off-set by greater proportion of private vehicle trips occurring while the engine is still cold
Reducing transport greenhouse production	Will depend upon the balance between reducing localised congestion problems and the growth in overall vehicle travel. May well see an increase. With greater proportion of private vehicle travel over short distances with cold engines, any improvements will not be linear.
Reducing other environmental impacts (e.g. noise)	As with other environmental objectives, no major improvements could be expected as a rule although in specific cases and locations some improvements may occur. Smaller parking stations should create fewer environmental effects through good design.
Increase social inclusion/ community liveability	Increased social contact and possibly some reduced vehicle travel impacts in key congested corridors through the use of public transport could be expected. Some increase in vehicle travel around the parking stations would potentially create adverse traffic effects on the local community. More parking stations make accessing the system by foot or cycle more possible (but not a focus of the park and ride system!)

Table 0.4 Initial assessment of Objectives by Park & Ride Type - Dispersed

Park and Ride Type: Dispersed	
Example	Portland, Oregon, US (Bus-based);
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is likely to be needed in the central city area, releasing land for more productive and efficient development. But this is not certain nor could be relied upon, given the relatively unplanned and spontaneous provision of parking in the suburban/peri-urban areas and the uncertainty whether the stations support centrally focussed public transport or not.
More cost-effective provision of parking for central city	Given the casual provision of parking, it is difficult to rely upon it so the reduction in parking demand in the central city may not be noticeably reduced. The uncertainty is unlikely to result in more cost-effective parking provision in the central city.
More economically efficient transport system	For a given travel demand, it is likely that the transport system will be more economically efficient as at least some trips will transfer from congested conditions to more efficient modes for dealing with the congested areas. Private trips are made in less congested conditions with public transport travel occurring in the more congested areas (presuming some public transport priority). Relatively short private vehicle trips to the wide range of potential sites reduces the overall proportion of private vehicle travel to public transport travel. Overall the generalised cost of travel is likely to have lowered.
Reducing congestion levels on urban radial routes	For a given level of demand, some reduction in congestion should occur. However, no examples have ever been cited, and generally the released supply is absorbed by new (in some places, suppressed demand) trips. The casual nature of the parking station supply infers that no intentional locating of the parking stock to avoid congested areas would occur.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled. Given previous comments regarding lack of impact on parking supply and confidence, it appears unlikely that noticeable reduced central city congestion would occur.
Reducing the need/pressure for increased road capacity	Given the lack of certainty of parking station supply and “random” locations, there is unlikely to be (and certainly little generic confidence could be had in) any reduction in pressure for other road network upgrades due to lack of confidence in the effects of the park and ride system.

Increases public transport use	Systems are generally integrated with wider public transport system, and as such the system increases catchments and access to the public transport system. So an increase in public transport use could be expected, but no information is at hand to quantify the extent.
Reducing local emissions/ pollution levels	Will depend upon the degree of congestion relief experienced with the system, but as congestion relief is not observed, noticeable reductions in emissions are not likely at the local level. The level of congestion relief is far from certain with the "random" locating of the parking stations not necessarily targeting where the greatest congestion relief may potentially be achieved.
Reducing transport greenhouse production	Will depend upon the balance between reducing localised congestion problems and the growth in overall vehicle travel. May well see an increase, due to greater private vehicle travel to parking stations that may involve travelling through some congested areas and longer distances to access the station.
Reducing other environmental impacts (e.g. noise)	As with other environmental objectives, no major improvements could be expected as a rule although in specific cases and locations some improvements may occur.
Increase social inclusion/ community liveability	Increased social contact and possibly some reduced vehicle travel impacts in key congested corridors through the use of public transport could be expected. Some increase in vehicle travel around the parking stations would potentially create adverse traffic effects on the local community. Joint use parking station areas may improve opportunities for mixed purpose trips focussed at the interchange point, improving liveability and social equity.

Table 0.5 Initial assessment of Objectives by Park & Ride Type - Collar

Park and Ride Type: Collar	
Example	Cincinnati, OH; Cleveland, OH; San Diego, CA; Albany, NY; Pittsburgh, PA; Atlanta, GA
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is needed in the central city area, releasing land for more productive and efficient development.
More cost-effective provision of parking for central city	For a given level of parking provision supporting the central city, it will probably be marginally cheaper to provide parking at the edge of the central city with slightly cheaper development costs than in the higher cost centre.

More economically efficient transport system	For a given travel demand, it is unclear whether the transport system will be more economically efficient. Private trips are still made in any congested conditions existing on the way to the central city, with public transport travel occurring only for a short distance in the congested central areas. Relatively long private vehicle trips in overall proportion to public transport travel makes for negligible travel efficiencies. Overall travel time and generalised cost of travel may increase due to fares, wait times at the interchange point and walk times not overcoming any congestion avoidance times/costs of the bus travel for the remainder of the journey. Overall the generalised cost of travel is likely to have risen.
Reducing congestion levels on urban radial routes	Almost certainly have no effect, as private vehicles are still travelling on these arterials all the way in to the edge of the central city to access the parking stations.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled.
Reducing the need/pressure for increased road capacity	Very little benefit, due to most pressure for improvements still would exist where the private vehicle travel occurs prior to reaching the parking station. Pressure for road capacity increases in the central city are not likely to be significantly different with or without the system operating.
Increases public transport use	Unlikely to result in increased public transport use, as the system still enables users to predominantly rely upon private vehicles for most of the travel and public transport does not provide sufficiently great benefits over very short distances to encourage new users to the system generally.
Reducing local emissions/ pollution levels	No benefits in most of the network, although if any congestion relief occurs in the central city, then some reductions may occur.
Reducing transport greenhouse production	The reduction through slightly less private vehicle travel to its ultimate destination is likely to be overcome by more trips enabled to the central city, which need to travel on congested arterials to reach the edge of central city parking stations, creating significantly more emissions.
Reducing other environmental impacts (e.g. noise)	No improvements in the suburban areas, with potentially some deterioration through increased private travel. Some benefits may result in the central city, if any congestion relief or reduction in private trips occurs.
Increase social inclusion/ community liveability	Some nominal increase in social contact through the short public transport trip at the end of the journeys. No other benefits apparent.

Table 0.6 Initial assessment of Objectives by Park & Ride Type - Nodal

Park and Ride Type: Nodal	
Example	Sydney
Park & Ride Objective	**Qualitative assessment and comment**
Reducing the amount of parking required in the CBD/ improve land use efficiency in CBD	For a given travel demand, less parking is needed in the central city area, releasing land for more productive and efficient development.
More cost-effective provision of parking for central city	For a given level of parking provision supporting the central city, it will be cheaper to provide some parking at the park and ride stations with cheaper development costs than in the higher cost centre. The possibility of joint development of the parking facilities at the suburban nodes could potentially provide additional efficiencies.
More economically efficient transport system	For a given travel demand, it is likely that the transport system will be more economically efficient. Private trips may be made in less congested conditions with public transport travel occurring in the more congested areas (presuming some public transport priority). However, private trips accessing key suburban nodes can still experience significant congestion around the nodes (malls). Relatively short private vehicle trips to the wide range of potential sites reduces the overall proportion of private vehicle travel to public transport travel. Overall the generalised cost of travel is likely to have lowered, but perhaps not significantly.
Reducing congestion levels on urban radial routes	For a given level of demand, some reduction in congestion should occur on the roads leading to the central city. However, no examples have ever been cited, and generally the released supply is absorbed by new (in some places, suppressed demand) trips. Private vehicle travel to the suburban nodes may further increase any existing congestion on the radial arterials surrounding those locations.
Reducing congestion levels in the CBD itself	For a given level of demand, likely to occur with slightly fewer vehicle trips and less circulation looking for parking spaces. Actual situation depends on how overall parking supply is managed, and whether additional trips have been enabled.
Reducing the need/pressure for increased road capacity	A temporary fix, as even with very successful systems, the reduced demand may represent up to 5 years of traffic growth. It would depend upon the nature and location of the growth and types of network improvements needed. Improvements for public transport priority will almost certainly be required. Pressure on the road network immediately surrounding the nodes/parking stations may result in demands for additional network improvements.

Increases public transport use	Depends upon whether the system is integrated with general public transport, although generally it is integrated. Isolated services operate in competition with general public transport, but there appears to be overall more people catching the bus/train despite being split between systems. Integrated systems clearly provide some benefit and growth, but the degree is unclear.
Reducing local emissions/ pollution levels	Will depend upon the degree of congestion relief experienced with the system, but as congestion relief is not observed (and may increase around the node), noticeable reductions in emissions are not likely at the local level. Less travel by private vehicle would generate lower emission levels, although this will not be linear due to a greater proportion of private vehicle trips occurring while the engine is still cold
Reducing transport greenhouse production	Will depend upon the balance between reducing localised congestion problems and the growth in overall vehicle travel. May well see an increase. With greater proportion of private vehicle travel over short distances with cold engines, any improvements will not be linear.
Reducing other environmental impacts (e.g. noise)	As with other environmental objectives, no major improvements could be expected as a rule although in specific cases and locations some improvements may occur.
Increase social inclusion/ community liveability	Increased social contact and possibly some reduced vehicle travel impacts in key congested corridors through the use of public transport could be expected. Some increase in vehicle travel around the nodes/parking stations would potentially create adverse traffic effects on the local community. More parking stations make accessing the system by foot or cycle more possible (but not a focus of the park and ride system!). Joint use parking station areas may improve opportunities for mixed purpose trips focussed at the interchange point, improving liveability and social equity.